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ENVIRONMENT

Planning for the Future

SMOKE MANAGEMENT FOR THE '90S

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SMOKE MANAGEMENT FOR THE '90s

Clean Air Policy Steering Committee

We Welcome Your Comments:

The Clean Air Policy Steering Committee has produced this discussion paper to examine the issues related to biomass burning and suggest management options. The committee is made up of staff from the Ministries of Environment, Lands and Parks (BC Environment); Forests; Energy, Mines and Petroleum Resources; Health; Agriculture, Fisheries and Food; Tourism; and Municipal Affairs, Recreation and Housing.

Smoke Management for the '90s is intended to stimulate public involvement in defining a smoke management policy for British Columbia. Your thoughts are most welcome on how we can ensure clean air and wisely manage the sources of smoke in our province. Response to this paper, received before May 1, 1992, will be used to develop the new policy. Comments may be sent to:

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Environmental Protection Division
BC Environment
Ministry of Environment, Lands and Parks
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Victoria, B.C.
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Meetings can be arranged by calling 387-9987.

Editor's Note: The recent reorganization of the provincial government has led to new ministry titles and responsibilities. The former Ministry of Environment, known as BC Environment, has now become part of the Ministry of Environment, Lands and Parks.

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EXECUTIVE SUMMARY

Purpose

Air pollution from the burning of organic material (biomass) is a growing problem throughout B.C., posing risks to human health and significantly reducing visibility. This discussion paper is an important step in developing an effective smoke management policy that will control the sources of smoke and thereby preserve air quality.

Smoke Management for the '90s examines the different kinds of burning and the resulting health/environment issues. It then suggests a wide range of options and management approaches aimed at reducing smoke-caused air pollution. The list of options and approaches is not all-inclusive, but is intended to stimulate discussion and perhaps open the way to new solutions.

Put simply, reducing woodsmoke requires that we pay more careful attention to what, when, where and how we burn:

- ***What*** — We need to decrease the quantity of biomass that goes up in flames and make sure that toxic, "nonbiomass" materials (such as plastics and tires) are not burned along with it.
- ***When*** — We have to burn less frequently and limit burning to times of good atmospheric dispersion.
- ***Where*** — Burns must be located so that people and communities are not exposed to an unacceptable concentration of smoke.
- ***How*** — It is crucial that we burn efficiently, releasing a minimal amount of emissions. This means making sure the biomass is dry and that the way we burn — be it an open fire, sawmill residue burner or woodstove — achieves as complete combustion as possible.

At the same time, we must make a major shift in how we view and use biomass itself. Traditionally, we have regarded leftover organic material as ***waste*** — an inconvenient pile of debris needing disposal by burning. "Woodwaste" is the well-worn term for such biomass, and that is usually how it is treated.

The truth is, though, that the wood scraps, sawdust, shavings, leaves and other organic materials left from such activities as logging, sawmill operations and land clearing form a valuable ***resource***. This biomass can be put to good use as chips for

pulp and fibreboard mills, feedstock to generate energy, or the material for compost and mulch.

Rather than labelling such material as worthless "woodwaste" or "garden refuse," we should recognize it as a beneficial byproduct. We need to change our habits and develop the technical ability to use biomass effectively, instead of sending it to the incinerator. This, in turn, will reduce our smoke problem.

Shifting to better ways of using and, when necessary, disposing of biomass is not just the responsibility of, for example, the forest industry alone, nor sawmill operators, nor woodstove owners. We are all in this together. Since most of us do some sort of burning, we all have a part to play in the solution.

Changing our old perceptions and burning practices will require strong resolve and assertive action. But the effort will be well worth it, ensuring fresh, healthy air for the British Columbians of today and tomorrow.

Background to this Paper

Smoke Management for the '90s was produced by the Clean Air Policy Steering Committee — a committee of seven provincial ministries — to provide the basis for consultation with interested British Columbians on the approach and contents of the new smoke management policy. This policy will become part of the future Clean Air Strategy, which the committee is also developing.

This discussion paper is one of t" e "companion documents" of *Environment 2001 — Strategic Directions for British* ' *umbia*. Released by BC Environment earlier this year, *Environment 2001* is a long-term strategy to address the urgent environmental issues facing us in this decade. *Smoke Management for the '90s* elaborates on the smoke management initiatives set out in *Environment 2001*. It shares the larger document's commitment to sustainable development, as well as to extensive public and stakeholder consultation.

Biomass Burning in B.C. and its Impacts

Wood burning was a crucial activity in our past and is still important today. We burn organic material for many reasons:

- to get rid of logging slash and prepare land for planting;
- to dispose of sawmill residue;
- to prevent wildfires;
- to enhance wildlife habitat and cattle range;

- to dispose of debris from agriculture, land development, construction and domestic gardening; and

- to heat our homes.

Rather than being a "natural" and harmless legacy from bygone days, however, smoke contains several pollutants that can trigger serious health problems. These include acrolein, aldehydes (such as formaldehyde), carbon monoxide, nitrogen oxides (NO_x), fine particulate matter, polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs). Many of the pollutants are strongly associated with chronic respiratory effects such as increased airway resistance and decreased vital capacity. Some hold a small risk of cancer, although the exact degree of risk is not yet known.

Biomass burning also creates a visual haze that can cover entire communities or even whole regions for weeks at a time, reducing visibility and hiding scenic vistas. The visibility issue is complicated by the fact that a very small amount of particulates can create the appearance of a major smoke emission.

There is some concern about the fact that biomass burning releases significant amounts of carbon dioxide ($C0_2$), a greenhouse gas. However, unlike fossil fuel combustion, biomass burning does not increase the long-term amount of $C0_2$ in the atmosphere. The reason is that biomass naturally releases $C0_2$ (when it rots) and reabsorbs it (when it is a growing forest). Biomass burning simply speeds up this cycle.

Prescribed Burning

Prescribed burning is a valuable and, in many cases, necessary tool. It is done mainly for silvicultural purposes (slash burning), but is also used to enhance wildlife habitat, improve cattle range, reduce wildfire hazard and dispose of land-clearing debris.

From a resource management perspective, eliminating all prescribed burning is not a practical option. The practice can be reduced, however. For example, the amount of wood residue from logging can be decreased, leading to less burning. To this end, the Ministry of Forests is enforcing a new "zero waste" policy that encourages sending low-grade to the sawmill, rather than burning it. Alternative site-preparation techniques can be used instead of slash burning, although more research has to be done to determine if the benefits would outweigh the costs.

Another option is to eliminate the burning of piles and windrows, and use the wood residue for power generation. In addition, emissions can be reduced by strategically timing prescribed burns for periods of good atmospheric dispersion and by using new methods that ensure rapid consumption of target residues.

The management approaches recommended to reduce smoke from prescribed burning include the following:

- Develop BC Environment and Ministry of Forests policies that will encourage the maximum use of wood residue throughout the forest industry. This should include minimizing on-site debris and, where possible, transporting residue to energy recovery facilities.

- Support research into fire behaviour and the site impacts of burning compared with the alternative of mechanical site preparation.

- Continue to improve the management of prescribed burning to reduce public exposure to particulates and air toxics, and minimize regional haze.

- Increase air quality monitoring. Expand continuous monitoring of fine particulate mass (PM_{10}) so that long-term changes can be effectively assessed and the data can be used as a regulatory tool.

Prescribed burning to remove land-clearing residue causes special problems. Frequently, the woody debris left from land clearing is burned with noncombustible and toxic materials, and tires are used as fire accelerants. Very noxious emissions can be released.

In this case, the proposed management approaches are to immediately stop the practice of using tires in land-clearing fires, throughout British Columbia. Methods and procedures should also be developed to put an end to land-clearing fires in areas where the potential for human health impacts is significant.

Residue Burning in the Forest Products Industry

Wood residue burning by sawmill operations is a waste management problem. Sawmills are burning wood residue inefficiently, keeping their operating costs to a minimum. As a result, the emissions from sawmill residue burners (especially teepee burners) cause frequent episodes of air pollution for many small B.C. communities, limiting visibility and leading to health problems.

This situation is especially unacceptable because the wood residue (trim ends, slabs, bark, shavings and sawdust) could be used as a clean-burning and renewable fuel, known as hog fuel. About half of the sawmill wood residue in the province is burned with no energy recovery, but most of it could be used for electrical generation, or as chipping for pulp and fibreboard mills.

The management goal here is to establish policies that motivate the forest products industry to burn its wood residue cleanly, recover benefits from the heat and, where possible, send the leftovers to a cogeneration facility or secondary manufacturer.

A new use for hog fuel is electricity generation by small independent power producers — solely for sale to B.C. Hydro. This area is now opening up due to recent policy changes by B.C. Hydro and the provincial government.

The management approaches recommended to both reduce smoke from sawmill residue burners and use the residue as a valuable resource are based on amending BC Environment's *Pollution Control Objectives for the Forest Products Industries*. The changes should be such that the following goals are achieved by January 1st, 1996:

- Eliminate all teepee or olivine burners in urban centres and smoke-sensitive areas. The wood residue should be diverted to electrical generation facilities and/or other users (pulp mills, fibreboard manufacturers, etc.). New emission objectives should be established for sawmills in these areas to promote the use of incinerators with the "best available control technology."

- In smoke-sensitive areas where diversion to alternative uses is not yet possible, BC Environment should promote incinerators that are fully capable of energy recovery and burn very efficiently (i.e. not a modified burner but a true multichamber incinerator).

- In remote areas (outside smoke-sensitive areas) where transport to generation facilities is not feasible, incinerators must be upgraded to reach high efficiency and produce an acceptable environmental impact. Landfilling must not be permitted.

- Other energy-extraction techniques should be examined, such as pyrolysis, gasification of wood residue, liquefaction and densification.

It is important that BC Environment provide wood-burner permit holders with details on the proposed permit changes, why they are necessary and when they should be accomplished.

Urban and Agricultural Burning

Biomass Burning in Municipal Areas — The burning of yard residue (leaves, grass clippings, prunings, etc.), and debris from municipal land development and construction creates a significant smoke problem. The issue is not so much quantity — the emission is relatively small — as proximity. It is common for people and neighbourhoods to be right in the middle of the smoke plume or very close to it. If the burning coincides with periods of restricted air circulation, the emissions can accumulate to unacceptable levels. In fact, they can be worse than those from a larger fire such as a prescribed burn.

What is in the smoke is another hazard. Wet materials are often burned with dry ones, and the burning itself is often inefficient, releasing substantial amounts of particulate and products of incomplete combustion. In addition, other refuse is often thrown in, such as plastics, rubber, insulation, coated wire and PVC pipe. This adds dioxins, furans, heavy metals and other air toxics to the regular pollutants in woodsmoke. Many of the compounds are well-known respiratory irritants. A very small portion are probably carcinogenic.

The many small, municipally operated landfills are yet another smoke source. They periodically burn refuse to reduce the bulk before burial. Plastics, rubber, rotting waste and inorganic waste all go into the fire, resulting in hazardous emissions.

Management approaches focus on the fact that much of the biomass from municipal land development, construction and backyard burning can be recycled into a useful product — compost — through household or community compost boxes. Municipalities should be encouraged to put an end to all yard residue burning.

Guidelines should be created for handling the debris from land development and construction, and on-site burning should be discouraged. New policies should also be developed with respect to burning municipal domestic and light industrial waste in municipal landfill operations — to prohibit the burning of unacceptable materials and prevent accidental or unlawful ignition.

Agricultural Burning — Fire is used in agriculture to dispose of crop residue, and control pests and disease. The grass seed growers in the Creston area burn stubble each year. This causes some local air quality problems. At the same time, though, it reduces the need for pesticides and synthetic fertilizers, and is vital to ensuring a sustainable crop. Smoke impacts should be controlled by scheduling burning for periods of adequate atmospheric venting.

Incinerating agricultural residue such as prunings from fruit trees, grape vines and raspberry canes appears to be less warranted. Burning is done mainly because it is the traditional practice and is an inexpensive method of disposal. The recommended management approach here is using the organic material for compost and mulch. If there are cases in which fire is essential to combat an outbreak of pests and/or disease, BC Environment can approve a one-time burn.

Residential Wood Burning

Wood burning for home heating can cause a marked decline in urban air quality, especially in mountainous areas. Unlike natural gas or oil, burning wood releases significant emissions of particulates and products of incomplete combustion, many of which are well-known respiratory irritants. Rather than floating outwards or upwards, the smoke tends to remain near the source — in or near people's homes.

British Columbia's climate, geography and settlement patterns make it particularly susceptible to this kind of air pollution. Valley bottoms — where many Interior communities are located — tend to have frequent, long-lasting periods of cold, stable air during the winter. Pollutants from woodsmoke can be trapped and concentrated near the ground, accumulating to very high concentrations during these "air stagnation" periods.

Inefficient woodstoves and poor burning practices by woodstove operators are also a major part of the problem. As B.C. has not set emission standards for wood-burning appliances, it is likely that very few woodstoves achieve the emission rates required in other jurisdictions in the Pacific Northwest. Therefore, two key management approaches include establishing emission standards for residential woodstoves and requiring woodstove certification to meet the standards. Public education on how (and why) to burn efficiently is also essential.

In other jurisdictions, woodstove emission abatement programs have led to a marked improvement in wintertime air quality. They can serve as good examples for how we can control woodsmoke in our province. The most successful programs combine public education with mandatory curtailment of emissions on poor air-quality days, enforcement of no-burn days and special exemption permits.

In British Columbia, the Municipal Act gives municipalities jurisdiction over controlling woodstove emissions. So far, however, only Cranbrook and Comox have taken steps to reduce woodsmoke. Other municipalities in B.C. have expressed concern, but are not prepared to deal with woodstove emissions on their own because they lack the necessary scientific knowledge and staff.

The proposed management approaches to residential wood burning emphasize that BC Environment should help municipalities reduce woodstove emissions to safe levels, by providing scientific and technical aid. If BC Environment could help identify problem areas, design air quality monitoring networks and establish model abatement programs, municipalities could easily deal with the routine aspects of running their own program.

In addition, particulate and meteorological monitoring should be improved, and the public should have access to the air quality index in affected communities. The Atmospheric Environment Service of Environment Canada could also play an important role by providing forecasts of air stagnation.

Conclusion

Woodsmoke is no longer just a romantic reminder of simpler times. It has become a serious cause of air pollution. The growth of our communities and industries has resulted in too many people burning too much, and too often. Moreover, the biomass left from other activities can often be used productively — for power generation, chipping for pulp and fibreboard mills, as well as compost and mulch.

The time has come to develop a thorough, effective approach to managing biomass burning — making sure that it is necessary, in the first place, and is carried out efficiently and with minimal impacts. By explaining the problems and suggesting solutions, this discussion paper is an important step towards a comprehensive smoke management policy. Public and stakeholder input is now vital to make sure the new policy reflects the needs and wishes of British Columbians everywhere.

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1

INTRODUCTION

A. Background

The smell of woodsmoke on a cold, clear night. It sparks feelings of coziness, the simple life and getting back to the good old ways. We British Columbians have a long, close bond with wood, fire and smoke. Both the native people and the pioneers burned wood for warmth and to cook their meals, as well as using fire to modify the land's vegetation.

Today we burn organic material (called "biomass") for many reasons:

- to get rid of logging slash and prepare land for planting;
- to dispose of sawmill wood residue;
- to prevent wildfires;
- to enhance wildlife habitat;
- to improve cattle range;
- to dispose of debris from agriculture, land development and domestic gardening; and
- to heat our homes.

But times have changed. What was once a fairly harmless practice has become a major source of air pollution. The expansion of our communities and industries has meant that too many of us are burning too much — and too often. People are becoming increasingly aware of the problem, as shown by the rising number of complaints about smoke from biomass burning.

Large smoke plumes can travel hundreds of kilometres and cause a visual haze covering entire regions. We have also discovered that the ingredients of smoke can cause significant health problems. The fact is that woodsmoke is not the romantic remnant of bygone days. It is now a threat to our health and well-being.

We need to cut down on the amount of smoke that goes into our atmosphere. This means unravelling our historic tie with biomass burning. Put simply, reducing

woodsmoke requires that we pay more careful attention to what, when, where and how we burn:

- ***What*** — We need to decrease the amount of biomass that goes up in flames and make sure that toxic, "nonbiomass" materials (such as plastics and tires) are not burned along with it.

- ***When*** — We need to burn less frequently and limit it to times of good atmospheric dispersion.

- ***Where*** — Burns must be located so that people and communities are not exposed to an unacceptable concentration of smoke.

- ***How*** — It is crucial that we burn efficiently, releasing a minimal amount of emissions. This means making sure the biomass is dry and that the way we burn — be it an open fire, sawmill residue burner or woodstove — achieves as complete combustion as possible.

At the same time, we must make a major shift in the way we view and use biomass itself. Traditionally, we have regarded leftover organic material as ***waste*** — an inconvenient pile of debris to be disposed of as cheaply as possible. "Woodwaste" is the well-worn term for such biomass, and that is usually how it is treated.

The truth is, though, that the wood scraps, sawdust, shavings, leaves and other organic substances left from such activities as logging, sawmill operations and land clearing are valuable ***resources.*** They can be put to good use as chips for pulp and fibreboard mills, feedstock to generate energy, or the material for compost and mulch.

Rather than labelling such biomass as worthless "woodwaste" or "garden refuse," we should recognize it as a beneficial byproduct. We need to change our habits and develop the technical ability to use biomass effectively, instead of sending it to the incinerator. This, in turn, will reduce our smoke problem.

We should also understand that we are in this together. Shifting to better and more efficient ways of using and disposing of biomass is not just the responsibility of, for example, the forest industry alone, nor sawmill operators, nor woodstove owners. Since most of us do some sort of burning, we all have a part to play in the solution

Changing our old beliefs and burning practices will require effort and foresight. But the effort will be well worth it, ensuring fresh, healthy air for the British Columbians of today and tomorrow.

B. Purpose

Smoke Management for the '90s examines the different kinds of burning in B.C. and the resulting health/environment issues. It then suggests a range of options and management approaches aimed at decreasing smoke-caused air pollution. The list of options and approaches is not all-inclusive, but is intended to stimulate discussion and perhaps open the way to new solutions.

This paper will provide the basis for gathering public and stakeholder input on controlling burning and reducing smoke impacts, as well as making better use of biomass. The information gained through the consultation process will then be used to develop a comprehensive smoke management policy for the province. The new interministry policy will improve upon the current situation, in which different ministries regulate burning to meet different ends. In turn, the smoke management policy will become an important part of the future Clean Air Strategy for British Columbia.

Smoke Management for the '90s is the culmination of many hours of research and discussion by the Clean Air Policy Steering Committee. This body is composed of staff from seven provincial ministries: Environment, Lands and Parks (BC Environment); Forests; Energy, Mines and Petroleum Resources; Health; Agriculture, Fisheries and Food; Tourism; and Municipal Affairs, Recreation and Housing. The committee was formed to develop both the provincial smoke management policy and the broader Clean Air Strategy. (Appendix 1 gives more details on the background of this paper.)

Finally, this discussion paper is closely linked to *Environment 2001 — Strategic Directions for British Columbia,* which was released by BC Environment earlier this year. *Environment 2001* is a long-term strategy to address the broad spectrum of urgent environmental issues facing us today, including atmospheric issues such as smoke. It reflects the provincial government's intention to move British Columbia to sustainable development over this decade.

As part of the *Environment 2001* package, several discussion papers have been or will soon be released, focusing in more detail on specific environmental and resource issues in the "flagship document." *Smoke Management for the '90s* is one of these papers, sharing the same commitment to sustainable development, and to extensive public and stakeholder consultation.

Sustainable development is the planet's hope for a healthy future. Put simply, it is economic development that is environmentally sound — within the limits required to sustain long-term environmental health. Such development ensures that our use of the environment and its resources today does not harm the prospects for their use in the future.

With respect to smoke management, sustainable development means burning biomass only when truly necessary (not just because "we've always done it this way"), and with the greatest efficiency and least possible environmental impact. It also means making every effort to use biomass residues constructively, rather than simply throwing them in the fire.

C. An Outline of *Smoke Management for the '90s*

Chapter 2 provides a general overview of biomass burning in our province — the extent and intensity of burning, the environmental issues and possible management approaches. In addition, it explains the jurisdictional responsibilities for biomass burning.

The following chapters (3 to 6) centre on the concerns surrounding specific sources of smoke in B.C. — prescribed burning, wood residue burning by the forest products industry, urban and agricultural burning and, lastly, residential wood burning.

Each chapter also describes options for reducing or eliminating the impacts of biomass burning, as well as the management approaches required to achieve these ends. Included are some of the major tradeoffs which will have to be considered in policy making.

More than anything else, it is institutional reluctance to embrace change that prevents real progress from being made on smoke issues. If we are to significantly reduce biomass burning, we must first overcome the momentum of many generations of unawareness or indifference. The options and management approaches in this paper are ways of introducing a measure of change.

2

BIOMASS BURNING IN BRITISH COLUMBIA

A. Introduction

It is clear that biomass burning is an environmental problem in our province. The studies that have been done indicate that the impact of woodsmoke on the environment is widespread and, in certain locales, quite significant.

The exact magnitude of the air quality problem is not so clear. It is difficult to get thorough information on the quantity of biomass burned, the way it is burned, and the amount and nature of the smoke. British Columbia is so big and burning goes on just about everywhere, every day. And each burn has unique emission characteristics — whether it be a wildfire, a slash burn, a logyard burn, a teepee burner or a woodstove.

Air monitoring programs carried out by BC Environment are normally directed at assessing impact from specific point sources. BC Environment has also done several joint studies with the Ministry of Forests to define the source profile of slash-burning smoke and to find out how it affects the air in a community. An inventory of woodsmoke from other sources (such as yard, land-clearing and landfill fires, and woodstoves) is not available. There are no reliable estimates of the volume of biomass burned annually, other than some broad surveys.

B. Air Pollutants Produced through Biomass Burning

The Combustion Process and its Byproducts

Combustion is a complex chemical process in which a hydrocarbon reacts with oxygen, producing heat and byproduct chemicals. When a simple hydrocarbon is burned under optimum conditions the reaction yields only carbon dioxide and water. As combustion efficiency decreases, or more complex hydrocarbons and other chemicals enter into the reaction, the chance of complex byproducts increases.

When biomass burns, the combustion process takes place in three distinct phases: pre-ignition, flaming and glowing (see appendix 2). The efficiency of biomass combustion depends on the fuel's moisture content, as well as the combustion temperature, oxygen supply and turbulence.

Wet biomass burns poorly. In order for biomass to burn freely, its water content must be less than 50 percent by weight (less than 25 percent is ideal). Generally, an oxygen-starved fire does not burn well either, increasing the chance of undesirable byproducts. Artificially induced turbulence, such as that found in high-efficiency fireboxes, dramatically increases combustion efficiency.

Approximately 50 percent of bone-dry wood is cellulose. The other 50 percent is made up of more complex hydrocarbons, including lignins, oils, fats, resins, waxes and tars. All biomass burning produces undesirable byproducts, although the exact composition and quantity of emissions vary greatly, depending on combustion efficiency. Many of these byproducts are considered to be air pollutants and have well-documented impacts on human health.

Health Impacts

The old view that "woodsmoke is natural and therefore harmless" is obsolete. Recent studies reveal that biomass smoke contains a myriad of compounds capable of harming human health. The major air pollutants in woodsmoke are acrolein, aldehydes (such as formaldehyde), carbon monoxide, nitrogen oxides (NO_x), fine particulate matter, polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs).

These are strongly associated with chronic respiratory effects, such as increased airway resistance and decreased vital capacity. Children, the elderly, and people with impaired lung function are particularly at risk. Table 1 describes how the pollutants produced by biomass burning affect human health.

For several years there has been debate in the air quality community over the significance of PAHs in woodsmoke. It is well known that PAHs, classified as "probable human carcinogens," adhere to very fine particulates, and can therefore penetrate to the deepest regions of the respiratory tract and stay there. The PAH concentration observed in areas affected by woodsmoke are so low that the cancer risk factors are very small, but not insignificant.

Given the present state of knowledge, one cannot justify restricting exposure to woodsmoke based solely on cancer risk factors. ***There is, however, ample justification to limit woodsmoke exposure because of its damage to lung function.***

There is some concern about the fact that biomass burning releases significant amounts of carbon dioxide ($C0_2$), a greenhouse gas. However, unlike fossil fuel combustion, biomass burning does not increase the long-term amount of $C0_2$ in the atmosphere. The reason is that biomass naturally releases $C0_2$ (when it rots) and reabsorbs it (when it is a growing forest). Biomass burning merely speeds up the cycle.

Table 1

Air Pollutants Associated with Biomass Burning

Pollutants	Impact on Humans
Acrolein	Acrolein can irritate the eyes and the respiratory tract.
Aldehydes (e.g. Formaldehyde)	At low concentrations (0.4 ppm), formaldehyde is an eye and respiratory tract irritant, and can cause headaches. It is also a probable carcinogen.
Carbon Monoxide (CO)	At low concentrations, CO is linked to an increased incidence of angina in people with heart disease. At high concentrations, CO is lethal because it replaces oxygen in the bloodstream.
Nitrogen Oxides (NO_x)	At low concentrations (0.3 ppm), NO_x cause bronchial congestion in asthmatics and children. At higher concentrations, they cause fluid collection in the lungs and fibrotic changes.
Fine Particulate Matter ($PM_{2.5}$)	Very fine suspended particulate matter ($PM_{2.5}$) penetrates to the lungs' alveolar region and may affect lung function. Studies show that prolonged exposure to high concentrations of fine particulates (PM_{10} above 150 micrograms per cubic metre) can lead to increased respiratory illness in children, aggravate asthma and contribute to chronic obstructive pulmonary disease. Very fine particulates also interact with visible light and cause a haze that limits visual range.
Polycyclic Aromatic Hydrocarbons (PAHs)	PAHs are among the most harmful of the products of incomplete combustion. Certain PAHs (e.g. Benzo(a)Pyrene) are probable human carcinogens. Exposure to certain PAHs is associated with a small, but not insignificant, cancer risk.
Volatile Organic Compounds (VOCs)	Certain VOCs, like benzene, are known human carcinogens. In addition, VOCs and NO_x are precursors to the formation of ground-level ozone, otherwise known as urban smog. Ground-level ozone is connected with respiratory irritation and illness, such as bronchitis and asthma.

Visibility Impacts

Perhaps one of the greatest impacts of smoke from biomass fires is the formation of regional haze. When slash burning or wildfires occur under inversion conditions the lower atmosphere becomes uniformly contaminated with smoke. This smoke tends to accumulate and limit visibility over vast areas, because there is little horizontal air motion under a ridge of high pressure. The same impact is often experienced on a smaller scale in the vicinity of a teepee burner, or when yard residue is burned in urban areas.

Woodsmoke is composed mainly of very small particulates, mostly in the submicron range (i.e. less than one-millionth of a metre). The diameter of these smaller particulates coincides with the mean wavelength of visible light. As a result, they are extremely efficient at scattering light. For example, adding only one microgram of this material, per cubic metre, to a perfectly clean air mass greatly reduces the visual range — from a theoretical maximum of 390 km to 290 km. An extra five micrograms shortens the visual range to 130 km.

The 1986 PANORAMAS study of the Oregon-Washington-Idaho region found that about 62 percent of very fine particulates in the atmosphere came from prescribed burning and wildfires. The situation is much the same in British Columbia.

C. Legislative Responsibility for Biomass Burning

The burning of biomass falls under the jurisdiction of several levels of government. For most of them, air quality is not the overriding concern. Only the Ministry of Environment, Lands and Parks (BC Environment) administers burning primarily to meet some kind of air quality objective, through its Environmental Protection Program. The Waste Management Act authorizes BC Environment to issue permits to discharge waste into the environment. Other acts give it similar authority.

However, there are exemptions to the Waste Management Act. These include the following:

- burning of leaves, foliage, weeds, crops or stubble;
- burning for land clearing, grading or tilling;
- fires set as defined by the Forest Act and Fire Services Act; and
- wood burning for home heating.

The exemptions lead to a situation in which varied levels of government are responsible for different aspects of biomass burning, with a broad range of goals. For

example, the Ministry of Forests' main interest in biomass burning is preventing forest fires. Municipalities also have jurisdiction over certain aspects of burning, through the Municipal Act. Municipalities deal with woodstove complaints, case-by-case, under nuisance bylaws. Meanwhile, municipal fire-safety bylaws require that backyard and land-clearing burning do not pose a fire hazard.

Although these exemptions appear to indicate that the Ministry of Environment, Lands and Parks has no authority regarding emissions from biomass burning, the government has preserved the ministry's overriding authority to maintain a healthy environment. Under the Environment Management Act, the Minister of Environment, Lands and Parks has the authority to curtail any source of environmental pollution if it has a "detrimental environmental impact" or if an "environmental emergency" exists.

D. Management Approaches — An Overview

Smoke Management for the '90s puts forth a variety of management approaches aimed at reducing the overall impact of smoke. All aspects of biomass burning need review. New management techniques should be adopted, if appropriate, and they should be solidly based on the principles of sustainable development.

The management approaches in this discussion paper are based on the recognition that reducing or eliminating harmful impacts requires more than simply saying "stop burning." As well, they are intended to decrease negative effects without seriously compromising the positive aspects of the burning activity — if that activity has merit.

The new approaches also take into account the pros and cons of different kinds of burning. Some burning activities are desirable, if not absolutely necessary. Some are economically desirable but environmentally damaging. And others have no redeeming values at all, persisting simply because they are an accepted custom.

Prescribed burning, for example, is a valuable and, in many cases, necessary tool to prepare logged sites for planting, enhance wildlife habitat and cattle range, and prevent wildfires. On the negative side, the smoke affects local air quality and produces a regional haze which degrades scenic vistas — an important tourism resource.

There are many possible management approaches to prescribed burning — from exploring alternatives to burning, to introducing emission reduction techniques developed in the Pacific Northwest. Expanded air quality monitoring is also suggested, especially in areas where visual impacts are a concern.

Sawmill residue burning, on the other hand, is simply a waste management problem. Sawmills are burning their wood scraps, shavings and sawdust inefficiently, keeping their short-term operating costs to a minimum. The management goal is to establish policies that motivate the wood products processing industry to burn its wood residue cleanly and to recover benefits from the heat.

Decades of study and practice point to extracting energy from sawmill residue as the overwhelming solution-of-choice where adequate supplies exist. Indeed, current technology — used in most comparable American operations — allows for more efficient combustion, with energy recovery partially offsetting the higher costs of construction and operation.

Burning in municipal areas is an outdated practice. It evolved from the previous century when the only way to remove the massive amount of land-clearing debris was by burning it. Today, many communities still let urban dwellers dispose of garden refuse by burning, with no consideration for air quality. As well, debris from construction and land development (scrap wood, tree stumps, plastics, coated wire, PVC pipe, etc.) is commonly burned, releasing particularly hazardous chemicals.

Burning at municipal landfills is another problem. In certain instances, municipal landfill permits (administered by BC Environment) authorize periodic burning of domestic refuse to reduce bulk before burying. All these practices result in substantial emissions of air contaminants near or in populated areas.

The management approaches in this case are aimed at reflecting current thinking on sound waste management, energy efficiency and environmental protection. A potential solution to much of the refuse-burning problem lies in using yard residue for community-scale composts. This would produce a usable product, improve air quality and decrease the amount of organic material in landfills. Efforts to reduce much of the paper and other recyclable biomass going to landfills will also help achieve this aim.

Wood burning for residential heating is an integral part of our heritage in British Columbia and it continues to meet a sizeable portion of our home heating demands. This practice has substantial merits, but also serious drawbacks. When too many wood-burning appliances (especially inefficient ones) operate under conditions of poor atmospheric dispersion, the smoke can carry a major risk of adverse health effects.

Management techniques developed in the U.S. Pacific Northwest have proven very successful in reducing woodstove impacts. We can use this pool of knowledge to create our own solutions. The techniques include:

- monitoring pollutants;
- regulating woodstove emission quality;

- providing incentives for replacing outdated woodstoves with more efficient models;
- passing municipal bylaws to restrict burning under poor venting conditions; and
- designating "no-burn days."

The few jurisdictions that administer successful abatement programs consider enforcement and monitoring to be the most critical components.

In summary, we need to find new uses for much of the biomass that is currently burned. The uses include chipping for pulp or fibreboard mills, compost, and feedstock for electrical generation facilities. The management challenge is to make sure these necessary changes are implemented on a reasonable timetable.

3

PRESCRIBED BURNING

A. Introduction

Smoke from prescribed burning sparks more public complaints to the provincial government than all other air emissions combined. Prescribed burning is mainly done for silvicultural purposes (slash burning), but it is also used to enhance wildlife habitat, improve cattle range, reduce wildfire hazard and dispose of land-clearing debris.

Extended periods of haze during the fall "burning window" prompt a fair percentage of the public to express its displeasure to the ministries involved (Forests or Environment, Lands and Parks) or anyone else who will listen — often the media.

Many people strongly suspect that their health is harmed by smoke from prescribed burns. The pollutants with known detrimental effects on health (the respiratory system, in particular) are acrolein, aldehydes, carbon monoxide, fine particulates, NO_x, PAHs and VOCs (see table 1). The burning of land-clearing residue causes especially hazardous emissions.

Prescribed burning also releases significant amounts of carbon dioxide ($C0_2$), a major greenhouse gas (B.H. Levelton & Associates, 1990). It must be noted, though, that if the woody debris were left to decompose naturally, much of the carbon in it would eventually be released as $C0_2$, anyway. With respect to the major kind of prescribed burning — slash burning — much of the $C0_2$ produced will be recovered by the new forest. Prescribed burning does result in a more rapid release of the carbon dioxide stored in biomass residue. But it does not necessarily contribute to long-term increases in atmospheric $C0_2$ levels.

Many people are irritated by the loss of familiar scenic vistas. Some in the tourism and agriculture industries think the smoke causes them financial losses. Still others see it as a symbol of poor forestry practices, mistakenly drawing a parallel between the deforestation of tropical rain forests and the regeneration of temperate forests. Whatever the cause, complaints are being received in growing numbers, accompanied by demands for solutions.

Visibility is the thorniest aspect of the whole prescribed-burning debate. A very small amount of particulates is required to create the appearance of a major smoke emission. Therefore, the concentration of fine particulates can be well within even the most stringent air quality guidelines and still generate public concern.

In response to these issues, the Ministry of Forests has made preventive changes to existing policies on prescribed burning. One of the key goals of the Clean Air Policy Steering Committee — and this discussion paper — is to provide the ministry with a sound basis for permanent revisions to both its smoke management and prescribed burning policies.

B. Prescribed Burning in British Columbia

Slash Burning

After an area is logged, a good quantity of woody residue remains. It consists of tree limbs, unmerchantable (rotten, shattered) timber, leaves, twigs and the like. To prepare a site for planting, a portion of this debris (mainly fine material) must be removed. The traditional method is to burn the site, either that fall or the following spring.

The burn is accomplished by igniting either the entire cut block or prepiled windrows. A great deal of residue also accumulates and is burned on landings — the sorting and staging areas located near the actual cut blocks, far from the destination sawmill. Residue piles are usually hand-lit late in the fall and left to burn out over the winter.

Fire is not always the preferred method of land treatment, but certainly the cheapest over the short term. Usually, short-term economics dictates the site prescription.

Since its inception in 1912, the Ministry of Forests has encouraged slash burning, especially on the coast. The rationale was to protect the remaining timber from fire and insects, and promote the establishment of a second crop. In 1938, legislation enabled the Vancouver Forest District to require slash burning, in recognition of the potential fire danger. This legislation was expanded, in 1967, to include the rest of the province.

Since the late 1970s there has been a vigorous effort to deal with the backlog of logged-over sites needing reforestation. To speed up the process, the Ministry of Forests encouraged site preparation (mainly burning). For instance, it set a policy of limited liability for "escapes" — to stimulate industry to aggressively use prescribed fire as a silvicultural site treatment. In short, if fire escaped from the burn area, the ministry would pay the resulting fire-fighting expenses, over $1,000. Applying prescribed fire also allowed the licensee to claim credit against stumpage fees.

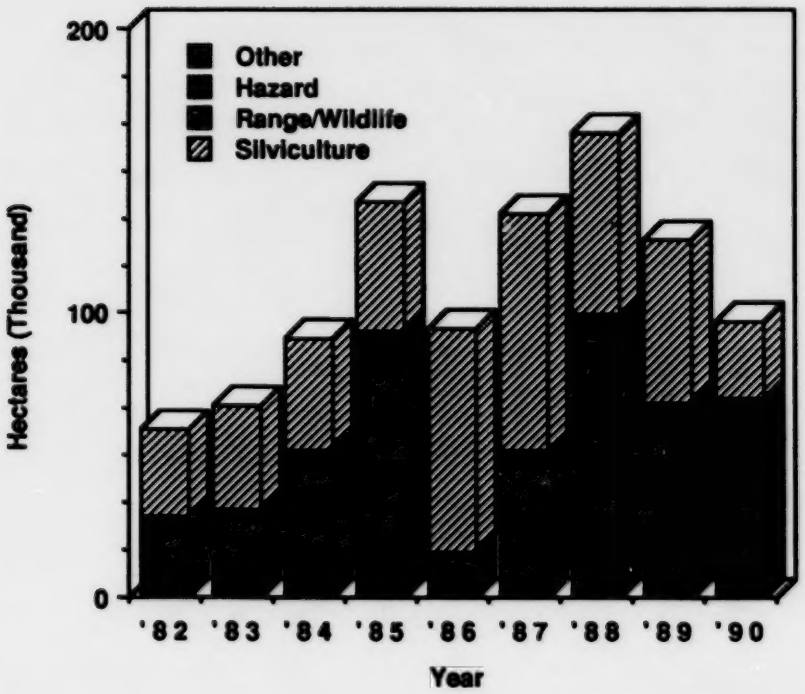
From 1982 to 1990, 50 percent of the prescribed burning in our province was done for silvicultural purposes (slash burning). The remainder was for wildlife habitat

enhancement (30 percent), range improvement (11 percent) and fire hazard reduction (nine percent).

Figure 1 shows the hectares burned under the Ministry of Forests' Class A (industrial) permits from 1982 to 1990. It points out the dramatic increase in burning for silviculture, coincident with a federal-provincial reforestation program called the Forest Resource Development Agreement (FRDA: 1986 to 1990). It also reveals the substantial amount of habitat and range burning that goes on from year to year.

Figure 1

Hectares Burned under Class A Permits, 1982-90



The Ministry of Forests administers any prescribed fires outside an incorporated area and closer than 1,000 metres to a forested area. All these fires are administered under either Class A fire permits or Class B (casual domestic) fire permits. The Class B permits are issued exclusively for small "hand-piled" burns conducted outside incorporated areas.

Thousands of Class A and B fire permits are issued annually. In the past, licensees with a Class A burning permit were only required to comply with conditions set by the Ministry of Forests' prescribed fire policy — to minimize the danger of wildfire (or escape) and to achieve the site prescription. Recently, smoke management policies were enacted to decrease smoke impacts. Although a significant improvement, they have not completely alleviated public concerns. All these policies are now under review.

Habitat Burns

Habitat burns are conducted to clear nonproductive land where fire has been excluded from the ecosystem by fire suppression methods. Much of this land is accounted for by a few large blocks of scrub vegetation that are burned off each spring in northeastern British Columbia.

Range Burns

Range burning is employed to enrich grass production in a number of cattle grazing regions. Since the 1930s, fire has been almost totally excluded from grasslands that would naturally experience fires every seven to 15 years. Burning is necessary to eliminate unpalatable species of grass. The restriction on range burns in recent years has caused some concern because it impedes efforts to enhance the land for grazing.

Burning to Prevent Large Wildfires

Fire-hazard-reduction burns are carried out regularly in the vicinity of several Interior communities where, in the absence of small wildfires, fine fuel accumulations reach dangerous levels. Without these controlled burns there is a high probability of a wildfire, which could cause considerable property loss and, possibly, human casualties.

Land-Clearing Fires

A small portion of the burns conducted under the Class A burning permits is for land clearing. This type of burning is frequently associated with right-of-way clearing for highways and utility corridors, as well as land development. Burning usually occurs right after logging — to clear the construction area of biomass (e.g. tree limbs, and stumps encrusted with soil and rocks).

In addition, BC Lands issues agricultural leases in British Columbia, on a lease/develop/purchase basis. In most instances, the preferred way to get rid of the debris from land clearing is by open burning.

Burning this material is often unacceptable from an environmental standpoint, especially near population centres. Because the material is frequently not dry enough to burn unaided, a fire accelerant must be used. It is common practice to bulldoze the debris into large piles (which frequently contain as much noncombustible material as combustible), pack used tires about the pile, douse it with diesel oil and allow it to burn for days or weeks. Materials such as tires should absolutely not be used as a fire-promoting agent. They produce very noxious emissions which are potentially quite harmful to human health.

C. Recent Policy Changes

The 1983 smoke management policy outlined for the first time procedures to reduce the impact of smoke from prescribed fires. This policy adopted air quality criteria set out by BC Environment. It also made provisions for curtailing burning if atmospheric conditions precluded the swift dispersal of smoke.

Environment Canada produces a daily "venting index" during the fire season to estimate the atmosphere's dispersive capability. All Class A permits are suspended during periods of "poor" venting conditions and, depending on local visibility and public complaints, sometimes during "fair" venting.

Recently, both these policies have been reviewed in response to mounting public pressure to reduce smoke. In 1988, the Ministry of Forests — in conjunction with the Ministries of Environment, Health and Industry — drafted a new policy on smoke management that greatly raised the profile of air quality considerations.

The interim policy, adopted in 1989, introduced the concept of managing smoke emissions to reduce impacts on the visual range (aesthetics). This was in addition to preserving BC Environment's air quality criteria related to human health. The interim smoke management policy also required each district to develop smoke management plans which, among other things, designated smoke-sensitive and visually sensitive areas and time periods.

In 1989, the Ministry of Forests reviewed its prescribed burning policy that regulates all Class A burns. The newly adopted interim policy provides further disincentives to wholesale burning by eliminating the policy of limiting liability on escapes. It also states that "prescribed fire will be used only after other site treatment options have

been examined and documented, and are determined not to be viable options." Thus, prescribed fire is no longer the treatment of choice.

Also in a state of change are procedures for assessing the need for burning and the effectiveness of prescribed burns. The Ministry of Forests is moving to a new system in which a silvicultural prescription is done for an area before harvesting, rather than after. Today, for example, a site preparation analysis (form FS—117) is completed before burning, followed by an evaluation of the success of the burn.

Over the last year, a Pre-Harvest Silvicultural Prescription (PHSP) process has been initiated whereby the postharvest fuel loading and fire risk are assessed prior to actual logging. Specific prescriptions are developed at this stage for both fire hazard reduction and silvicultural site preparation. In this way, alternative site treatments become viable options, and it is possible to evaluate their effectiveness compared to burning.

D. Options to Reduce Smoke Impacts of Prescribed Burning

There are two main approaches to reducing the impacts from prescribed burning: eliminating the need to burn and reducing the emissions from burning. This section explores several examples of each approach, as well as options to manage the special problems posed by land-clearing burning. It ends by describing current air quality monitoring and making proposals for future monitoring — to ensure that the effectiveness of any policy changes can be evaluated.

Eliminating Burning

From a resource management perspective, stopping burning altogether is not a practical option. If the Protection Branch of the Ministry of Forests could not selectively burn, the fire danger from vast quantities of accumulating slash would pose an unacceptable risk of wildfire — to human life and property, wildlife and the forest itself. Moreover, fire is sometimes necessary to ensure biodiversity, which is essential to the health of ecosystems. And some sites simply cannot be prepared for planting without burning because other forms of treatment are less desirable from a silvicultural viewpoint.

For many years, slash burning has been considered an acceptable and low-cost method of preplanting site treatment. Without burning, all sites presently clearcut would have to be prepared by an alternative site treatment. These new methods may be prohibitively expensive and, in certain instances, cause more site disruption.

On the other hand, some forest ecologists believe that present burning practices are detrimental to the soil. They think that reducing the amount of land burned would minimize nutrient loss and soil degradation, benefiting the site in the long term.

The Ministry of Forests has recently started research to compare slash burning to other forms of land treatment like mechanical site preparation. At present, there is not a large body of research on this topic. It is far from certain if the benefits of alternative site preparations outweigh the costs. What is certain, though, is that if biomass is removed from logged-off areas by mechanical site preparation, new ways will have to be found to use the wood residues.

The Ministry of Forests is enforcing a new "zero waste" policy that encourages the use of low-grade wood left on logging sites. This policy initiative will transfer leftover biomass from the cut block to the mill site. When nonprime logs are processed at the mill a smaller percentage of the log is used, resulting in more residue. With more wood scraps arriving at mill sites, as well as logyards, new methods of utilizing them will have to be devised.

Eliminating certain classes of burns, such as piles and windrows, would reduce air quality impacts later in the fall when the fires are usually set. The residue would have to be removed from the site, possibly to an electrical generation facility. In some locations this treatment could be prohibitively expensive. But in areas where a great deal of this material is available, including the residue in a generation facility's fuel supply may help make such an endeavour more economic.

Severe restrictions on burning — for instance, prohibiting all fall burning — would force land managers to either accept the increased costs and risks associated with summer burns or develop alternatives to burning. This option has the benefit of eliminating smoke emissions during the time of year that traditionally experiences the worst dispersion. Although site preparation costs may dramatically escalate as a result, they may be offset by energy recovery and less site damage.

The present situation, in which burning is restricted to periods of good air circulation in the fall and spring, still affects air quality. It has yet to be seen if the smoke management plans called for in the interim smoke management policy have a positive impact on air quality, especially visibility.

In most cases, these smoke management plans require the cessation of burning when local visual range falls below a set limit. The new procedures may help reduce visibility problems and health-related impacts. The disadvantage to land managers is that, by adding restrictions upon restrictions, all burning (beneficial or not) may be precluded. A backlog of burns could develop, which would either persist and pose a fire danger, or be treated by other, more expensive methods.

Stopping wildlife and range burning will lead to the loss of habitat and grazing land, and create a severe fire hazard. Similarly, putting an end to fire-hazard-reduction

burns will expose some communities to unacceptable fire risks. It is clear that a total ban on all prescribed burning without a careful examination of the pros and cons would not be in the best interest of British Columbians.

Reducing Emissions

Emission reduction strategies for slash burning were pioneered by the U.S.D.A. Forest Service in the Pacific Northwest (Ward, 1989). The Ministry of Forests encourages such techniques and has included them in smoke management plans.

The strategies include a number of burning procedures that rapidly consume the target residues while leaving other residues untouched. This can be accomplished through a modified ignition technique, careful choice of light-up time and removal of excess residues before the burn. Rapid mop-up of smouldering fires also reduces the local air quality impacts.

These techniques hold promise, as emissions can be substantially reduced and site prescriptions better met. However, many of them are still in the experimental stage and have yet to be fully evaluated in a field setting in Canada.

Removing residue, possibly to a cogeneration facility, could be prohibitively expensive and may rob the site of nutrients from future decomposition. Mechanical removal may also damage the site more than burning. This issue will have to be fully explored before the wood residue can be included in a fuel inventory for electrical generation.

Alternatives to Land-Clearing Fires

Alternatives to burning land-clearing debris have not been explored in our province. Today, the simplest and most environmentally destructive method of disposal is accepted practice. The goal of people engaged in land clearing is to get rid of the unwanted biomass as quickly and cheaply as possible, which means burning material that, by nature, does not lend itself to rapid combustion. An improvement to the present situation is not hard to imagine.

For any positive changes to be take place here, the way land-clearing debris is managed will have to be radically altered. In rural settings, for instance, there should be a requirement that only well-seasoned, carefully piled and clean materials be burned.

In densely populated regions, innovative solutions will have to be sought. One example comes from a new company in the Lower Mainland that contracts out the services of an efficient "pit burner" to dispose of land-clearing residue. The unit consists of a portable blower, placed so that an air curtain is created over a rectangular burning pit. This produces rapid and complete combustion.

Management techniques from other jurisdictions could easily be incorporated into B.C. guidelines for using and, where necessary, disposing of this biomass. In Seattle and many other urban areas in the United States, this type of burning is banned.

The Puget Sound Air Pollution Control Authority (PSAPCA) requires that all land-clearing residue in the Seattle-Tacoma-Everett area be ground up and screened for recycling. Woody residue contaminated with inorganic material is used as mulch, mixed woody and inorganic materials are used as soil conditioner, and inorganic materials contaminated with woody residue are used as construction material. The PSAPCA has promoted the development of a market for this recycled product. In many cases the new product replaces "virgin" materials, which can then go on to some better use (Crumbaugh, 1991).

Air Quality Monitoring

At present, BC Environment does limited air quality monitoring on prescribed burning. Since 1987, under a joint Environment-Forests program, there has been occasional sampling of particulates and PAHs on smoky days during the slash-burning season. Both "contaminated" and "background" samples have been obtained in urban, rural and forest settings.

In addition, since 1988 there has been visibility monitoring during snow-free months in Kamloops and Kelowna. Some of BC Environment's ambient air monitoring stations (e.g. Kamloops, Kelowna and Cranbrook) which operate continuous particulate monitors are very useful for analyzing the dynamics of regional haze events.

Other sites with hi-vol samplers are of limited value since particulate samples are only taken every six days, providing 61 24-hour samples per year. They are more helpful for determining mean particulate (TSP and PM_{10}) concentrations, and variance about the mean, on an annual basis.

If the government wants to quantify any improvements in air quality brought about by its new prescribed burning policy, the present continuous particulate monitoring network will need upgrading and expansion. A system of visibility monitors would also prove useful, as the visual/aesthetic aspect of slash burning is critical. In fact, decisions on burning may well hinge on visibility measurements in the future, making uniform and reliable measurements very important.

Once relationships are established between visibility and fine particulate mass (PM_{10}) for a region, the Ministry of Forests would be able to regulate burning — based, in part, on the present fine particulate loading. This is vastly superior to the current system of qualitative visibility assessments. As well, if a maximum PM_{10} concentration were specified as a condition in a burning permit, the archived data would be a permanent and reliable method of tracking industry compliance with ministry policy.

E. Management Approaches

The following management approaches could be used to reduce the smoke impacts of prescribed burning:

- Develop BC Environment and Ministry of Forests policies that will encourage the maximum use of wood scraps throughout the forest industry. This should include minimizing on-site debris and, where feasible, transporting excess residue to energy recovery facilities.

- Support research into fire behaviour and the site impacts of burning compared with the alternatives of no treatment or mechanical site preparation. This will broaden the present range of options.

- Continue to enhance management of prescribed burning — to reduce public exposure to particulates and air toxics, minimize regional haze and preserve important scenic vistas. The Ministry of Tourism will compile an inventory identifying valuable tourism areas and peak operating times.

- Expand continuous monitoring of fine particulate mass (PM_{10}) to effectively assess long-term changes and utilize the data on a real time basis as a regulatory tool.

- Immediately stop the practice of using tires as a fire-promoting agent in land-clearing fires, regardless of where the burn is to be conducted.

- Develop methods and procedures to stop land-clearing fires in areas where the potential for human health impacts is significant.

Some issues arising from these new approaches are outlined below:

- The added cost of alternatives to slash burning may have negative impacts on the forest products industry, particularly the marginal operations. The government may ultimately bear some of this cost in the form of reduced tax and stumpage revenues.

- Overzealous recovery of biomass from logged sites, for electrical generation, could deprive the soil of the essential nutrients needed for sustainability.

- Additional constraints on burning might eliminate beneficial burns (which enhance wildlife habitat and cattle range), desirable burns (in "fire" ecosystems for forestry management) and necessary ones (which reduce fire hazard).

4

RESIDUE BURNING IN THE FOREST PRODUCTS INDUSTRY

A. Introduction

Many small communities in the province experience frequent episodes of poor air quality because of sawmill residue burning in teepee burners. When dispersion is poor, smoke can accumulate and cause respiratory problems (Vidal, 1990). Flyash is a persistent nuisance for nearby residents. Smoke plumes and layered hazes caused by wood residue burning are a frequent visual blight in many valleys.

Individual forest product companies have to run their burners to meet the conditions in their Waste Management permits. Generally, the permits stipulate a maximum smoke opacity and a maximum time that the required levels can be occasionally exceeded (e.g. during startup, production breaks and shutdown). Companies meet the objectives with widely varying degrees of success. Many teepee burners are out of compliance with their permits — some significantly so.

B. Sawmill Residue Burning in British Columbia

Some leftover wood is inevitable in the course of processing raw logs into lumber, plywood, shakes and shingles, and chips for pulping. About 80 percent of the raw logs delivered to large, modern B.C. sawmills is converted into merchantable wood products. Smaller, less efficient mills that do not have access to chip markets use under 50 percent of the log.

The forest products industry generates a variety of wood residues, consisting of trim ends, slabs, bark, shavings and sawdust. Provincewide, about half of this material is incinerated with no energy recovery, but most of it could be used in secondary manufacturing or to generate electricity.

Depending on the location in B.C., sawmill residue is viewed either as a liability or an asset. On Vancouver Island, where natural gas supply has been restricted and oil is expensive, the residue is much sought after by the pulp and paper industry. Known as "hog fuel," this biomass is used to generate steam for process heat and electricity. In the Cariboo region, on the other hand, there is little market for hog

fuel. It is viewed as a waste and is disposed of in the cheapest manner possible. Clearly, economics plays a large role in determining how sawmill residue is perceived.

Most sawmills in British Columbia get rid of their wood residue by incineration in a steel-shelled (teepee or beehive) burner or a refractory brick (olivine) burner. In 1988, there were about 120 burners operating under permit by the Waste Management Branch. Many smaller sawmills simply "open burn" wood residue each month or semiannually, after getting approval from both the Ministry of Forests and BC Environment. A very few are allowed to landfill their residue.

Because of their rudimentary design and typically poor state of repair, teepee burners seldom work efficiently. Emissions are difficult to characterize due to the highly variable combustion regimes in any given burner over time, and inconsistencies from burner to burner (Boubel, 1968; Casey, 1975). Any change in fuel feed rates, moisture content and composition leads to excessive smoke and flyash.

Generally, the resulting pollutants consist of an ever-changing mixture of carbon monoxide and dioxide, nitrogen oxides, aldehydes, PAHs, VOCs, and large and small particulates (Sandberg, et. al., 1978).

Refractory brick burners are more efficient than teepee burners, mainly because of their silo shape and the heat-retaining ability of their brick walls. They generally create less smoke, if they are well operated and maintained. However, none of the refractory brick burners in this province are capable of energy recovery.

The present methods of dealing with wood residue are unsatisfactory from both an air quality and a resource management perspective. Many small forest-industry towns in B.C. have suffered from teepee burner emissions, which have affected the health of residents and created an aesthetic problem. Moreover, simply disposing of material which is a potentially clean-burning and renewable fuel violates the principle of sustainable development in a healthy environment — a principle to which the provincial government is strongly committed.

Compliance History of Teepee Burners

When the Pollution Control Branch (now the Environmental Protection Program) was created in the mid-1960s, one of the problems it inherited was unacceptable emissions from unmodified teepee burners — those not employing a number of combustion-enhancing features.

After a public inquiry, the first *Pollution Control Objectives for the Forest Products Industry* were published in 1971. These objectives specified that "the disposal of wood residue in unmodified burners be discontinued by January 1, 1975." The point was made that modified burners were available to reduce emission problems. These new burners could control the over- and under-fire air, and the burner temperature.

The pollution control objectives recommended that the teepee burner be phased out entirely. The replacement was to be multiple-chamber incinerators, capable of both burning efficiently and recovering energy.

Quesnel was the only area where unmodified teepee burners were completely phased out. In March 1972, an order-in-council eliminated several local burners there because flyash was contaminating the wood chip piles at the new Cariboo pulp mill. The pulp mill was expected to use all the hog fuel produced in Quesnel. However, it soon became apparent that a great surplus still existed.

The Waste Management Branch then issued a permit for a wood residue landfill. The landfill was eventually filled and shut down. Since that time, it has been plagued by leachate problems and fires caused by spontaneous combustion. The branch later issued a permit for incineration in one, and later three, modified teepee burners.

Since 1975, most sawmills have continued to use the modified teepee burners to burn wood residue. Very few, if any, of the multiple-chamber incinerators were ever built. A few larger mills have installed boilers so that energy can be extracted to heat-drying kilns.

The new pollution control objectives (Mackenzie, 1977) make no reference to the type of burners required — except to say that they must meet certain discharge opacity levels, and not exceed certain levels of total suspended particulate (TSP) and dustfall in the receiving environment.

The Pollution Control Branch's efforts to force improvements to teepee burners resulted in temporary air quality improvements for many areas affected by the unmodified burners. The modified burner reduced discharge opacity, lessening the impact of both TSP and dustfall. But today these modified burners frequently exceed permit levels because of their poor design and combustion control, inadequate fuel conditioning and generally poor maintenance.

C. Options to Reduce Wood Residue Burning

A solution to the issue of wood residue burning is not hampered by a lack of studies and committee recommendations. A great number of studies have been done documenting how much wood residue is generated yearly and what options exist for utilization. This section briefly examines the wood residue inventories and residue utilization studies, and discusses recommendations from other reports.

Hog Fuel Inventories

A variety of agencies have published research on the current and projected surplus of hog fuel available at mill sites for the Interior and North Coast. A number of studies by Reid, Collins & Associates Ltd. preceded B.C. Hydro's proposal to install a cogeneration facility in Quesnel (B.C. Hydro, 1974; BCWWECC, 1978; H.A. Simons, 1978). The goal of these studies is to define precisely the long-term hog fuel supply in the Interior, by region.

Forestry Canada (Pacific Forestry Centre) also did a great deal of research on the amount of residual fibre at mill sites and in the forest, under the ENFOR (ENergy from the FORest) program. The program examined many aspects of the biomass-to-energy conversion process (McDaniels, 1982; McDaniels, 1987; Nagle, 1987; Forestry Canada, 1987, 1987a and 1989). Selected findings are summarized in table 4.

In 1977, the British Columbia Woodwaste Energy Coordinating Committee (BCWWECC) was created. It was chaired by the B.C. Energy Commission and included personnel from a number of provincial and federal agencies. The committee's report outlined the hog fuel supply and demand in the North Coast and Interior for 1976, and made projections for 1980 and 2000. Totals for these regions are as follows:

Table 2

Summary of Hog Fuel Production, Use and Surplus for the North Coast and Interior Regions — in BDUs*

Year	Total	Use	Surplus
1976	5,260,000	1,345,000	3,915,000
1980	5,766,000	2,191,000	3,575,000
2000	6,753,000	4,035,000	2,718,000

Source: Table 19, p. 40 (BCWWECC, 1978)

*1 BDU (bone dry unit) = 2,400 lbs oven-dried hog fuel

A later report completed by Reid, Collins & Associates for Forestry Canada summarizes the hog fuel supply-and-demand situation in the North Coast and Interior for the year 1986 (Forestry Canada, 1987). Totals are given in table 3.

Table 3

Summary of Hog Fuel Production, Use and Surplus for the North Coast and Interior Regions — in BDUs*

Year	Total	Use	Surplus
1986	6,447,500	2,438,800	4,008,700

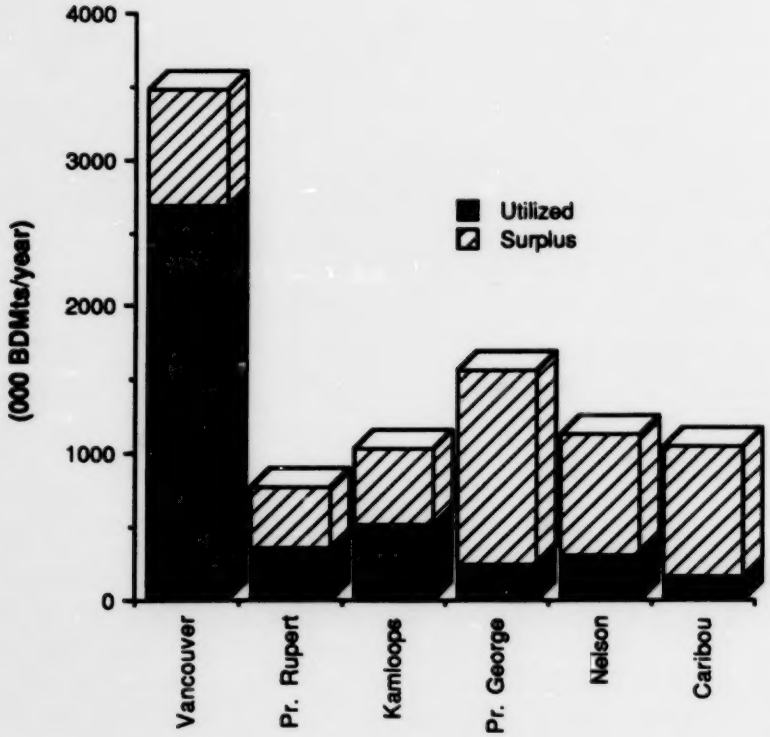
Source: Table 4, p. 13 (Forestry Canada, 1987a) *1 BDU = 2,400 lbs oven-dried hog fuel

Both these studies indicate that about half the wood residue generated by mills in the North Coast and Interior is surplus. Although this comparison shows that more wood residue is being used than before, the amount of residue being produced is steadily rising, too — so the surplus actually increases by two percent over time. There is also a lack of opportunities for utilizing hog fuel for power generation and heat extraction, which the 1978 study assumed would be developed.

A recent study completed for the Ministry of Forests' Mill Residue Task Force (Ministry of Forests, 1990) indicates that, in 1989, all regions had a substantial surplus of mill residue (figure 2). Moreover, mill owners, "on Vancouver Island in particular, were concerned about future outlets for hog fuel once natural gas becomes available to pulp mills that have been their usual market."

Figure 2

Total Wood Residue by Forest Region



The ENFOR program looked at the potential residue available for energy conversion across the province. As the price of the residue increases, more sources of biomass become available. This includes mill residue, sortyard residue, forest residue, merchantable surplus, salvage, stand conversions and plantations. Table 4 summarizes the program's findings.

Table 4

Total Forest Biomass Available in B.C. from Various Sources: As a Function of Cost of Residue (in BDUs, 1990 Estimates)

Cost Range ($/BDU)	Potential Sources Available	Additional Biomass Available	Total Biomass Available
0 to 15	mill residue (current)	8,156,173	8,156,173
16 to 30	+ additional mill residue	1,910,635	10,066,808
31 to 45	+ noncommercial harvest + logging +sortyard residues	2,101,044	12,167,852
46 to 60	+ noncommercial harvest + logging + sortyard residues	4,379,353	16,547,204
61 to 75	+ noncommercial + logging residue + plantations	6,929,637	23,476,841
Over 75	+ noncommercial + logging residues	13,324,529	36,801,370

Source: Table 1, p. 19 (McDaniels, 1987)

These results are interesting in that they show how economic forces affect the supply. The low-cost residues are largely those available at the mills. These differ from the estimates of total hog fuel production listed in tables 2 and 3 because Vancouver Island is included in the ENFOR analysis. As the price per bone dry unit (BDU) rises, the supply increases — first from sortyards, then logging residue and then plantations. Though these are just estimates, they do show that for many areas a great deal of biomass is available for energy conversion beyond the logyard gate, at a marginal increase in cost.

Burning wood residue in efficient electrical-generation facilities reduces a host of air quality impacts. It eliminates the particulate-PAH-VOC problem. CO_2 emissions stay relatively the same, but methane emissions from decay are reduced. It is true that new emissions are generated by the biomass recovery process. However, these

impacts are more than offset by ending the need to either burn nonrenewable resources (natural gas or coal) or build new, environmentally costly dams to provide the same electrical capacity.

In the near future, a number of new Ministry of Forests policies will likely result in more wood residue at mill sites and logyards, increasing the hog fuel production figures. These include:

- the new "zero waste" policy, which encourages the use of low-grade wood left on logging sites; and
- the new smoke management and prescribed burning policies, which promote greater use of woody debris remaining in the forest.

Utilization may also be expanding soon due to the growth of industries which use "white" scrap wood (particle board and pulp mills). In Williams Lake, for example, Cariboo Fibreboard is proposing to build a plant that will take part of the surplus hog fuel to produce particle board. If the export market for such products grows, there will no doubt be entrepreneurs seeking supplies of raw materials. Other jurisdictions have used surplus hog fuel as feedstock for the chemical industry or to produce gas. Only two British Columbia studies examining these potential uses could be located (McCann, 1978; B.H. Levelton & Associates and H.A. Simons International Ltd., 1986).

Despite these developments, it is likely that the present large surplus of hog fuel in the North Coast and Interior will persist. When natural gas becomes available on Vancouver Island, hog fuel may be partially displaced in certain instances (e.g. kiln dryers), possibly creating a surplus there as well. Unless options such as electricity generation are exploited, the hog fuel situation will not change significantly in the years to come.

Electricity Generation Studies

In 1988, BC Environment produced a number of studies to determine the potential supply of hog fuel for wood-fired cogenerating facilities — based on wood residue figures provided by the forest products industry (BCMOE, 1988; 1988a; and Leung, 1988).

These studies, like those presented above, show a large surplus of hog fuel in the North Coast and Interior. For instance, in 1986, the estimated power potential of the 26,565,000 cubic meters (4,635,000 BDUs) of the wood residue disposed of by incineration was 759 megawatts (MW) — distributed over 36 individual sites. Two sites had over 50 megawatts potential; nine had 30 megawatts or more (Leung, 1988).

More recently, the Ministry of Forests commissioned two reports — to update the 1986 figures from Forestry Canada (1987a) study and refine estimates for certain areas

where cogeneration is most likely to occur. The update of the Forestry Canada study is being completed by Stewart-Ewing Associates and is expected to be somewhat more comprehensive than the 1987 report. H.A. Simons (International) Ltd. is doing the second study. It will be of special interest to those considering developing the energy potential of wood residue.

Forestry Canada has recently finished a review (Forestry Canada, 1991) of its own major study (1989), which examines the expected influence of wood residue in the province's energy sector to 2010. The 1989 study includes estimates of the amount of wood residue that can be delivered to various parts of B.C. to supplement the existing hog fuel surplus. It also details the costs and benefits of electrical generation compared to other energy sources.

The most recent and detailed examination of hog fuel supply in Williams Lake was recently completed by Sandwell Swan Wooster (1989) for the 55-megawatt Williams Lake Generating Station. It looks at the hog fuel supply for the (then) proposed plant in detail, mill by mill. In addition, the report focuses on the supply that is potentially available from sawmills in the northern and southern Cariboo.

According to numerous studies, a large, stable quantity of hog fuel has existed for several decades in the North Coast and Interior. And it is well known that burning wood residue to generate electricity can eliminate or reduce many local air quality problems.

Despite this situation, B.C. has not realized its potential to develop wood-residue-to-electricity facilities. Although the technology to generate steam, and hence electricity, from this renewable resource has been readily available for decades, projects such as the proposed Quesnel Thermal Generating Station have not been realized. Why? Mainly because economics have not been favourable enough to motivate the industry to voluntarily pursue such projects (even without including the environmental costs).

B.C. Hydro's Electricity Purchase Policy

If the economics were right, small independent power producers (IPPs) could exploit the large, ongoing surplus of hog fuel in mainland British Columbia. Until recently, B.C. Hydro had a virtual monopoly on producing hydroelectric power for sale in the province. The situation began to change dramatically in December 1988. That is when B.C. Hydro issued a request for proposals from independent power producers to supply 150 MW of power to the domestic market. As well, the utility welcomed expressions of interest in supplying 400 to 600 MW of power to the export market.

Previously, the utility had encouraged electricity production by self-generation load displacement, in certain instances. But this was the first time it sought electricity supply from producers generating power with the main purpose of selling it to B.C. Hydro.

Self-generation load displacement usually involves pulp mills burning wood residue or black liquor in boilers to produce steam. Since these operations need both electricity and process steam, an electrical cogeneration project that uses high-pressure steam to drive turbines and the low-pressure exhaust steam to cook woodchips is ideal.

Right now, about 20 percent of the province's energy needs is being met by hog fuel burning at some of the province's pulp mills. One load displacement agreement, signed by B.C. Hydro in 1989, involved a no-interest loan by the utility to Howe Sound Pulp and Paper Corporation at Port Mellon. It was for an 85 MW cogeneration facility that will use wood residue as the major fuel component.

The Celgar pulp mill expansion at Castlegar will also include electricity load displacement using wood residue. Other expressions of interest for such cogeneration have been received by B.C. Hydro and the Ministry of Energy, Mines and Petroleum Resources from pulp mill operators in various parts of British Columbia.

Unfortunately, the geographical location and size of the wood residue supply do not perfectly meet the needs of the pulp mills interested in self-generation load displacement. Significant pockets of wood residue will remain unless a free-standing IPP is set up to exploit the resource. For this to happen, the IPP must be able to turn a profit.

In 1989, the first IPP to propose electricity generation from wood residue signed a contract with B.C. Hydro. The NW Energy Corporation, which will operate a 55 MW plant in Williams Lake, is due to start production in 1993. The Williams Lake facility will use 535,000 tonnes of wood residue annually, and the electricity generated will be used to supply the domestic market.

POWEREX, a wholly owned subsidiary of B.C. Hydro serving the export market, has also short-listed a proposal by Long Lake Energy Corporation to export electricity by building and operating a combined wood residue/gas thermal plant in the Houston area.

The Williams Lake Generating Station will be producing power for more than B.C. Hydro's avoided cost. In other words, the difference between what it costs the station to produce power from biomass and what B.C. Hydro pays amounts to several million dollars more a year. Under a special "environmental premium" arranged by Cabinet, this added cost to B.C. Hydro will be deducted from the yearly dividend that the utility pays to the government.

Recently, B.C. Hydro has received more expressions of interest for wood-residue-fired cogeneration in various regions. In order to ensure that more wood residue thermal plants will be developed, Cabinet has approved an environmental credit to continue the policy direction established by the environmental premium policy.

Under the environmental credit policy, B.C. Hydro has been directed to hold a request-for-proposals (RFP) for wood residue only — to acquire approximately 110 MW of power. The utility will be able to apply an environmental credit of up to 25 percent of its avoided costs when evaluating responses to this RFP. These additional costs, justified by the environmental benefits that will be captured, will be passed on to B.C. Hydro ratepayers.

D. Management Approaches

Management approaches to sawmill residue burning centre on the need to amend BC Environment's *Pollution Control Objectives for the Forest Products Industries* — to stop both incineration without energy recovery and landfilling as methods of biomass disposal. It is recommended that the following goals be achieved by January 1st, 1996:

- Eliminate all teepee or olivine burners in urban centres and smoke-sensitive areas — such as transportation corridors, recreation areas and other areas frequented by many people. The wood residue can be diverted to electrical generation facilities and/or other users (pulp mills, fibreboard manufacturers, etc.).

- Establish new emission objectives for sawmills in urban centres and smoke-sensitive areas to prohibit rudimentary-type incinerators and promote "best available control technology."

- In smoke-sensitive areas where diversion to alternative uses is not yet possible, BC Environment should promote incinerators that are fully capable of energy recovery and burn very efficiently (i.e. not a modified teepee burner or olivine burner, but a true multichamber incinerator).

- In remote areas (outside smoke-sensitive areas) where transport to generation facilities is not feasible, incinerators must be upgraded to reach high efficiency and produce an acceptable environmental impact. Landfilling must not be permitted because of the unacceptable environmental risk.

- Other energy-extraction techniques could be considered — such as pyrolysis (destructive distillation), gasification of wood residue, liquefaction (conversion to chemicals and liquid fuels) and densification (making wood pellets or briquettes).

- BC Environment must provide permittees currently incinerating wood residue with details on the proposed changes to their permit, the

rationale behind the changes and a schedule outlining target dates for the changes.

BC Environment will work closely with industry during the transition to more stringent environmental standards to insure that these can be adopted without undue economic impact.

5

URBAN AND AGRICULTURAL BURNING

A. Introduction

Most of us have spent an afternoon raking the leaves and then burning them, savouring the smell of smoke in the crisp, autumn air. Little did we realize that this seemingly wholesome practice could be an environmental problem. The truth is that burning our yard residue (such as leaves, grass clippings, prunings) and our household trash can create a health hazard.

As well as clouding the air, smoke from yard burning contains pollutants that can trigger respiratory problems. All of us are at risk, but especially vulnerable are the elderly, young children, and people who already have breathing ailments. Organic debris from municipal land development and construction is usually burned, too, adding to the smoke problem. Another source is the many small, municipally operated landfills, which periodically burn refuse.

These kinds of burning are regulated with very little consideration for air quality but, rather, from a fire safety and waste disposal perspective. Except for landfill burns, they are exempt under the Waste Management Act, and are not covered under the Forest Act unless the municipality is near forested land.

Local governments regulate such burning under the Municipal Act. This usually involves a burning bylaw and a system of burning permits. In unincorporated areas, the Ministry of Forests usually administers the burns.

Agricultural burning for residue disposal, and disease and weed control is yet another common practice that must be reconsidered. This chapter examines the issue of urban and agricultural burning from an air quality viewpoint — with special attention to the potential impacts on human health.

B. Biomass Burning in Municipal Areas

Exactly how much biomass is burned in municipalities is not known. It is probably much less than the other major smoke sources in British Columbia. But the small amount that is burned is carried out in such a manner that its impact is maximized.

Burning refuse (such as plastics and rubber) in or near settlements results in substantial, hazardous emissions. The emissions not only include particulates and products of incomplete combustion (see table 1), but also dioxins, furans, heavy metals and a host of air toxics — right where people live, and breathe. Many of these are well-known respiratory irritants. A very small portion are classified as probable human carcinogens (Core, 1984). The following sections detail how this burning is carried out and the possible impacts.

Yard Residue Burning

Across B.C., the traditional and common way to deal with yard residue is open burning. However, most municipalities impose some sort of restriction on when the burning can take place. Many confine it to special spring and fall periods, which are determined and announced by the fire chief. Some municipalities permit yard burning on weekends only, some for an entire two-week or month-long period. A few allow burning year-round, except during the fire season. And a very few municipalities have banned it altogether.

In unincorporated areas within a kilometre of a forest, the Ministry of Forests regulates yard fires through a Class B (domestic) burning permit. These fires are scheduled for a brief interval when the fuel is dry enough to be burned, but the surrounding area is not so dry as to present a serious fire hazard. In most areas the burn periods occur in early spring and late fall.

The wide variety of regulations under municipal and Ministry of Forests authority stem from the fact that this type of burning is exempt under the Waste Management Act.

Yard fires can create a significant amount of smoke for two main reasons: the sheer number of people burning in a confined area all at once and generally poor burning practices. Often, the debris to be burned is not completely dry, or contains dry material mixed with wet material. In many cases, the people doing the burning do not understand the fundamentals of combustion and make a smouldering, smoky fire. Sometimes, people throw in waste that should not be burned, such as plastics, treated wood and tires. This produces very harmful emissions.

Since the burn periods are scheduled weeks or months in advance, it is impossible to predict the fate of the smoke. Backyard burning tends to cluster around the weekend, when people are doing yard work, usually during times of calm, clear weather. If these burns coincide with periods of poor atmospheric dispersion the emissions can accumulate to unacceptable levels.

In Kamloops, for instance, BC Environment has documented periods of poor air quality that can be attributed to yard fires. It has found that the concentration of particulates during periods of backyard burning are as high or higher than when the area is heavily affected by other biomass fires, such as prescribed burning. The

concentration of PAHs is up to 10 times higher than that normally observed during a bad slash-burning episode.

Construction Debris Burning

Debris from land development and construction work within municipal and regional district boundaries is usually burned under a permit from the fire chief. In unincorporated areas within a kilometre of a forest, regulation is by a Ministry of Forests Class B burning permit. This burning often takes place on demand, but is avoided during periods of fire danger in Interior communities. As with backyard burning, some communities no longer permit burning for land development, while others restrict it to varying degrees.

Allowing the on-site burning of construction debris also contributes to local air quality problems. Scrap wood piles can contain plastic packaging, insulation, PVC pipe, coated wire and other waste materials that are definitely not biomass. The scrap wood itself has likely been treated with some antisapstain chemicals or preservatives, which may release hazardous chemicals when burned. In many jurisdictions, burning construction debris is considered a dangerous and outdated practice.

Municipal Landfill Burning

A major source of smoke in many smaller municipalities comes from burning domestic and light industrial waste at landfills. The waste is burned to decrease its bulk before burial. The incineration is usually conducted under a Waste Management refuse permit, issued by BC Environment. Sometimes landfill burning results from spontaneous combustion or arson. The resulting emissions are less acceptable than those expected from backyard burning — as more often than not plastics, rubber, rotting waste, and inorganic waste (e.g. batteries) are set on fire.

C. Agricultural Burning in British Columbia

Some agricultural activities depend on burning to get rid of residue, and to control disease and weeds. The best example of this is the yearly burning of stubble by the grass seed growers in the Creston area. Although this causes some local air quality problems, it creates environmental benefits, too. It reduces the need for pesticides (to kill rodents and insects) and synthetic fertilizers.

If the grass seed industry could not burn stubble, it would have to adopt less efficient agricultural practices or shift to annual rather than perennial crop production. In both cases, the returns and sustainability of a quality grass crop in southern British Columbia would be in question.

On the other hand, burning agricultural residue — fruit tree and grape vine prunings, raspberry canes, etc. — appears to be less warranted. It is carried out as an inexpensive and traditional disposal method. Although not substantial in terms of the total biomass burned each year, the fires do result in smoke and haze in urban areas adjacent to agricultural regions. A prime example occurs in the Okanagan Valley each spring, when the burning of prunings contributes to a noticeable haze in the valley.

D. Options to Urban and Agricultural Burning

The Rabbitt Commission

In 1988, the provincial government appointed the Rabbitt Commission to investigate the government's role in managing municipal solid waste. In its report, the commission noted that nearly a quarter of the material being sent to landfills is organic. Much of the organic material is yard debris.

The Rabbit Commission also noted that in the eastern U.S., where landfill space is at a premium, several states have banned the dumping of yard residue. Instead, municipalities have been told to implement leaf-composting programs. Pioneered on a large scale in that region, several successful projects have shown that leaf composting is a low-tech, relatively low-cost disposal method, yielding a composted product with a ready market.

In our own province, some municipalities have very limited leaf-composting programs. However, most continue to landfill garden refuse, while some allow burning as well as landfilling.

Several B.C. communities are starting to experience a shortage of landfill space, just as the eastern United States has. If the government eliminates yard burning and land-clearing burning without providing alternatives, the landfill shortage will become even worse. Properly implemented alternative treatments, on the other hand, will extend the life of present landfills. Given these circumstances, the ideal solution to deal with most of our yard debris is to compost it on a community-wide basis — directly recycling it into a useful product.

Yard Residue Burning

Following the Rabbitt Commission, BC Environment announced a provincial strategy for managing municipal solid waste. The goal is a 50-percent reduction in B.C.'s solid waste by the year 2000, with the government giving management planning assistance to regional districts. A major part of the solid waste strategy is to

stop organic material from going into landfill-bound waste. As mentioned above, organic yard residue can be effectively dealt with by community composting.

Construction Debris Burning
It is no longer acceptable to exempt the land development and construction industries from proper waste management practices. All debris from land development and construction activities should be managed in the same way as land-clearing debris, and regular municipal domestic and light industrial refuse.

Municipal Landfill Burning
At present, some Waste Management landfill permits are being amended as they come up for review — to eliminate burning. There is, however, no policy to completely prohibit landfill burning, and many permits will still allow periodic fires under the existing policy.

BC Environment's recent *Review of Objectives for Municipal Landfills* contains a number of recommendations that, if adopted, will both prohibit the burning of unacceptable materials and implement procedures to help prevent accidental or unlawful ignition. The ministry recognizes that it is inappropriate to continue to allow burning, in the light of new information on the emissions and their potential impacts on human health. If adopted, the new guidelines will go a long way towards remedying this problem.

Agricultural Burning
Since agricultural burning occurs on such a limited and intermittent basis, the atmospheric impacts can be mitigated by the route outlined for yard residue and prescribed burning. Tree and vine prunings should be composted in the same manner as yard debris. If there are cases in which fire is essential to combat an outbreak of pests and/or disease, BC Environment can approve a one-time burn.

The conflicts arising from stubble burning by grass seed growers can be resolved by scheduling burning to occur during periods of adequate atmospheric venting. In Creston, for example, guidelines for burning have been jointly developed by BC Environment and the Ministry of Agriculture, Fisheries and Food to alleviate a contentious air quality problem. If successful, it may serve as a useful model for similar situations.

E. Management Approaches

To reduce smoke from urban and agricultural burning, and use the biomass productively, the provincial government should assist municipalities in the following areas:

- Give advice on the hazards associated with burning:

  — yard residue;
  — municipal domestic and light industrial refuse;
  — land development and construction debris; and
  — agricultural residue.

- Upgrade the monitoring of particulates, PAHs, dioxins, furans, heavy metals and other air toxics to determine the environmental impacts caused by burning these materials.

- Provide advice on burning alternatives practised in other jurisdictions.

- Encourage municipalities to eliminate all yard residue burning in favour of alternative treatments such as community composting, as recommended by the Rabbit Commission.

- Develop guidelines for handling land development and construction debris. On-site burning should be discouraged.

- Develop new policies on burning municipal domestic and light industrial waste in landfill operations.

Some potential conflicts arising from these new approaches have been identified as:

- Funding for monitoring, technical assistance and educational campaigns is not provided for in existing BC Environment or municipal budgets. An equitable cost-sharing arrangement between the various levels of government will have to be struck.

- New markets for composted material will have to be found. Existing markets for "virgin materials" will be disrupted if community composting begins on a provincewide scale.

- Unincorporated areas may soon have to accept responsibility for regulating the burning now covered by Ministry of Forests Class B permits. But a shortage of funding and manpower may place these areas at risk. Therefore, added costs to unincorporated areas and/or regional districts will have to be rationalized at some level of government.

6

RESIDENTIAL WOOD BURNING

A. Introduction

Keeping a blazing fire going while the cold wind howls outside is a part of our heritage. We have long passed the pioneer days in B.C., but wood burning still fulfils a major part of our heating needs. In 1982-83, for example, it met about a quarter of the province's residential heating demand. And during 1988, about 10 percent of the homes in B.C. Hydro's service used wood as the major heat source. Many of us also like woodfires for aesthetic reasons, too, enjoying the smell of woodsmoke in the house, the crackle of the fire and its cosy warmth.

Today we live in such densely populated communities that smoke from wood burning can create an environmental problem. Old habits and perceptions die hard. Smoke curling out of chimneys may seem "natural," refreshingly old-fashioned and harmless. But the reality is that in some towns and cities woodstoves are now a major source of air pollution.

Unlike gas and oil combustion, wood burning releases substantial amounts of pollutants that can affect human health — some quite seriously. The pollutants include particulates and products of incomplete combustion (see table 1). Many of these are well-known respiratory irritants and a very small portion are probable human carcinogens. Children, the elderly and people with impaired lung function are most at risk.

This chapter explores the impacts of burning biomass for residential heating, together with the nature of the woodsmoke problem in British Columbia and the government's response to date. It ends by considering the possible management approaches to addressing the problem of woodsmoke pollution.

B. Residential Wood Burning in British Columbia

Reliance on wood heat is concentrated outside the Lower Mainland and southern Vancouver Island. It is largely a phenomenon of the smaller population centres, particularly in the Interior where winters are more severe, and there is a relatively abundant and inexpensive fuel supply. Recent surveys show that as B.C.'s urban population grows, the percentage of homes relying on wood for heat is decreasing

(Forestry Canada, 1989). Despite this downturn, the absolute amount of wood burned in the smaller centres may actually increase as these centres grow.

British Columbia's climate, geography and settlement patterns make it particularly susceptible to woodsmoke problems. Being mostly mountainous, the province has some of the poorest local regimes of atmospheric dispersion in Canada. In addition, B.C.'s valley bottoms tend to have frequent, long-lasting periods of cold, stable air during the winter.

This combination of geography and climate is especially significant for many Interior communities that are located in valley bottoms — pollutants there can be trapped during "air stagnation" periods, accumulating to very high concentrations . Communities with a high potential for woodsmoke problems include Nelson, Cranbrook, Terrace, Williams Lake, Quesnel, Penticton, Merritt, Salmon Arm, Comox and Campbell River.

The manner in which woodstoves are operated has as much to do with the problem as meteorology and geography. A recent survey by the Environment Youth Corps in Smithers found that a good number of woodstove users operate their appliances inefficiently. Not only do they use more wood and run a high risk of chimney fire, but they also contribute disproportionately to their neighbourhood's air pollution. Often the stove design is inadequate (imprecise control, wrong size). Poor fuel conditioning (wet wood) and poor burning practices (oxygen starvation) are also to blame.

As British Columbia has not set emission standards for wood-burning appliances, it is likely that very few woodstoves achieve the emission rates required in other jurisdictions in the Pacific Northwest (e.g. Oregon).

Wood burning is at its peak when the atmosphere's capacity to disperse emissions is at a minimum. On cold, clear and calm nights people tend to try to make their final charge last all night by damping the air supply as much as possible. The smoke from this smouldering fire has a high concentration of pollutants, and it tends to remain near their source, rather than floating outwards or upwards.

The greatest impact from woodstoves frequently occurs where people spend a great deal of their waking and sleeping hours: near or inside their homes. Woodsmoke particles are so tiny that they seep into houses — even through closed doors and windows.

C. Management Options for Wood-Burning Emissions

Jurisdictional Issues

Emissions from residential wood burning are exempt under the Waste Management Act. Jurisdiction for controlling woodstove emissions is clearly within the authority granted under the Municipal Act. As well, the Ministry of Energy, Mines and Petroleum Resources believes wood burning is best administered at the local level. However, the Ministry of Health and individual municipalities are reluctant to regulate this activity.

When the Waste Management Act was drafted in the early 1970s, smoke from wood-burning appliances was not a significant air quality problem. It was only following the "energy crisis," in the mid-seventies, that the first real hazards associated with woodstoves began to emerge. To offer some guidance on appropriate levels of regulatory control, the next section reviews woodstove abatement programs in other jurisdictions in the Pacific Northwest.

Woodstove Abatement Programs in Other Jurisdictions

Since the mid-1980s it has been widely recognized that a marked decline in urban air quality occurs in mountainous areas where wood burning for home heating is common. The U.S. Environmental Protection Agency estimates that in 1982 woodstoves contributed:

- 12 percent of the national (U.S.) total particulate emissions;
- 7 percent of national total CO emissions; and
- 40 percent of national total PAH emissions (Super, 1985).

In response to worsening urban air quality a number of jurisdictions have instituted woodstove abatement programs. Most are located in the western cordillera, mainly in the Pacific Northwest. The best examples of these are in Missoula, Montana; Puget Sound, Washington; Juneau, Alaska; and Whitehorse, Yukon Territory. Here is a summary of the four programs:

> **Missoula, Montana** — After a series of public meetings and the formation of a citizens' advisory board, the City of Missoula initiated a woodstove curtailment program.
>
> The program combines public education, mandatory curtailment of emissions on poor air-quality days, enforcement of no-burn days and special exemption permits. The city also has a fairly sophisticated methodology for predicting days of poor air quality. The program has led to a marked improvement in wintertime air quality.

Juneau, Alaska — With its steep, mountainous terrain, Juneau experiences serious air quality problems during winter in the Mendenhall Valley, a residential area. Fairly intense, persistent inversions in this box canyon prevent woodstove emissions from dispersing.

Since 1982, the city has been running a woodstove abatement program which incorporates no-burn days, public education, mandatory curtailment, and exemptions. After an initial three-year period of growing pains, the program now enjoys overwhelming public support. This is due entirely to a dramatic improvement in winter air quality. The program is described in Gilbertson (1987).

Puget Sound, Washington — The Puget Sound Air Pollution Control Authority (PSAPCA) is responsible for maintaining ambient air quality in the Seattle-Tacoma-Everett area of Washington State. Rather than being concentrated in a local valley, this particular woodsmoke problem occurs in a variety of ways across a large urban centre.

After a great deal of investigation, PSAPCA embarked on an abatement program that is a combination of voluntary and mandatory no-burn days, and public education. Its experiences are summarized in Maykut (1987).

Whitehorse, Yukon Territory — The City of Whitehorse is the first Canadian city to pass a woodsmoke bylaw. The suburb of Riverdale, located in a small, isolated side-valley, has long been known to experience poor air quality in winter. A study by the Environmental Protection Service (Environment Canada) in the mid-eighties defined the problem. Officials at the protection service recommended a curtailment program to city officials, much like those detailed above.

After an initial period of reluctance, the city embarked on a program of "cautious enforcement." A mandatory curtailment program, with enforcement, was initiated during the winter of 1987-88. This resulted in a striking improvement in Riverdale air quality. After the public realized the connection between air quality and woodstoves nearly all opposition to the no-burn days evaporated. This program is described fully in Pulleyblank, (1988).

The elements of a model woodsmoke-curtailment program are also explored in the *Summary of the Proceedings of the PNWIS-APCA Woodheating Curtailment Workshop* (Batson, 1987).

Woodstove Abatement Programs in British Columbia

Today, very few municipalities in British Columbia are prepared to deal with woodstoves on their own. In the past year, a number of them have requested help with woodsmoke problems. They lack good understanding of the nature of the problem and the fundamentals of an abatement program. Moreover, issues such as air quality guidelines, dispersion meteorology and woodstove certification are complex.

So far, only two B.C. municipalities have tried to solve the woodsmoke problem — Comox and Cranbrook. Comox has recently passed a bylaw calling for no-burn days, based on visual assessment.

Cranbrook has passed a woodstove abatement program with much assistance and urging from BC Environment (Kootenay Region). Its curtailment program officially began in November 1990, when two educational pamphlets were issued to every Cranbrook household. One pamphlet describes the local "woodsmoke index" and the rationale behind voluntary curtailment activities. The other is a BC Environment educational pamphlet on woodstoves and air pollution.

Individual municipalities must pass and enforce their own woodstove abatement bylaws. Still, BC Environment can play a key role in addressing the woodstove pollution problem by providing scientific and technical aid. Smaller municipalities cannot be expected to hire staff to deal exclusively with air quality concerns. If the ministry could offer help in identifying problem areas, designing monitoring networks and setting up model abatement programs, municipalities could easily deal with the daily routine aspects of running such a program.

The Atmospheric Environment Service (Environment Canada) could also play an important part by providing forecasts of air stagnation for communities affected by woodstoves. Assuming that a community has the capability of monitoring particulate concentrations on a continuous basis, it must know the future state of the atmosphere to plan for curtailment (e.g. no-burn periods). Preliminary discussions on this kind of BC Environment/Environment Canada assistance have already taken place.

There are still two obstacles to developing such programs: the lack of air quality guidelines for inhalable particulates (PM_{10}) and the lack of emission standards for residential wood-burning appliances. BC Environment is working on new PM_{10} guidelines as part of the Clean Air Strategy. However, woodstove emission and efficiency standards are not even under discussion.

Since emission standards have already been set by other jurisdictions (EPA, Oregon) adopting these would be relatively straightforward. Several labs in Vancouver have already developed the capability to test and certify woodstoves to the U.S. standards.

D. Management Approaches

Here are some ways that the provincial government could help municipalities reduce woodstove emissions to safe levels:

- Provide scientific and technical assistance to municipalities (e.g. through BC Environment's Air Resources Branch) to help determine the severity of their woodsmoke problem.
- Develop model emission-reduction programs such as woodstove certification and public education, and/or woodstove emission-abatement programs.
- Improve particulate and meteorological monitoring, and provide public access to the air quality index in affected communities.
- Educate municipalities about government actions on woodstove pollution by coordinating activities with Municipal Affairs, Recreation and Housing.
- Work with Environment Canada (Atmospheric Environment Service) to ensure municipalities have all the tools necessary to carry out curtailment.

Some potential conflicts arising from these new approaches have been identified as:

- Funding for monitoring, technical assistance and educational campaigns is not provided for in the existing budgets of BC Environment and the Ministry of Municipal Affairs, Recreation and Housing. An equitable cost-sharing arrangement between the various levels of government will have to be struck.
- New emission requirements for woodstoves may cause the demise of the small, marginal woodstove manufacturers who are technically unable to meet the new requirements.

APPENDIX 1

Background to *Smoke Management for the '90s*

In response to the growing number of public complaints about smoke from biomass burning (e.g. slash burning, teepee burners, woodstoves) the Ministry of Forests and BC Environment struck the Smoke Management Steering Committee. The committee's function is to integrate smoke management policy across the province. The ultimate goal is to manage the sources of smoke and preserve air quality.

The Smoke Management Steering Committee is composed of three working-level subcommittees, the chairs of which form a management committee. This structure is headed by the Clean Air Policy Steering Committee — a group of assistant deputy ministers (ADMs) and senior managers from the following seven ministries: Environment, Lands and Parks (BC Environment); Forests; Energy, Mines and Petroleum Resources; Health; Agriculture, Fisheries and Food; Tourism; and Municipal Affairs, Recreation and Housing. The present committee is the largest and most broadly based ever assembled to consider the questions of preserving air quality and reducing smoke-caused pollution. Figure 3 shows the interrelationship of the two committees.

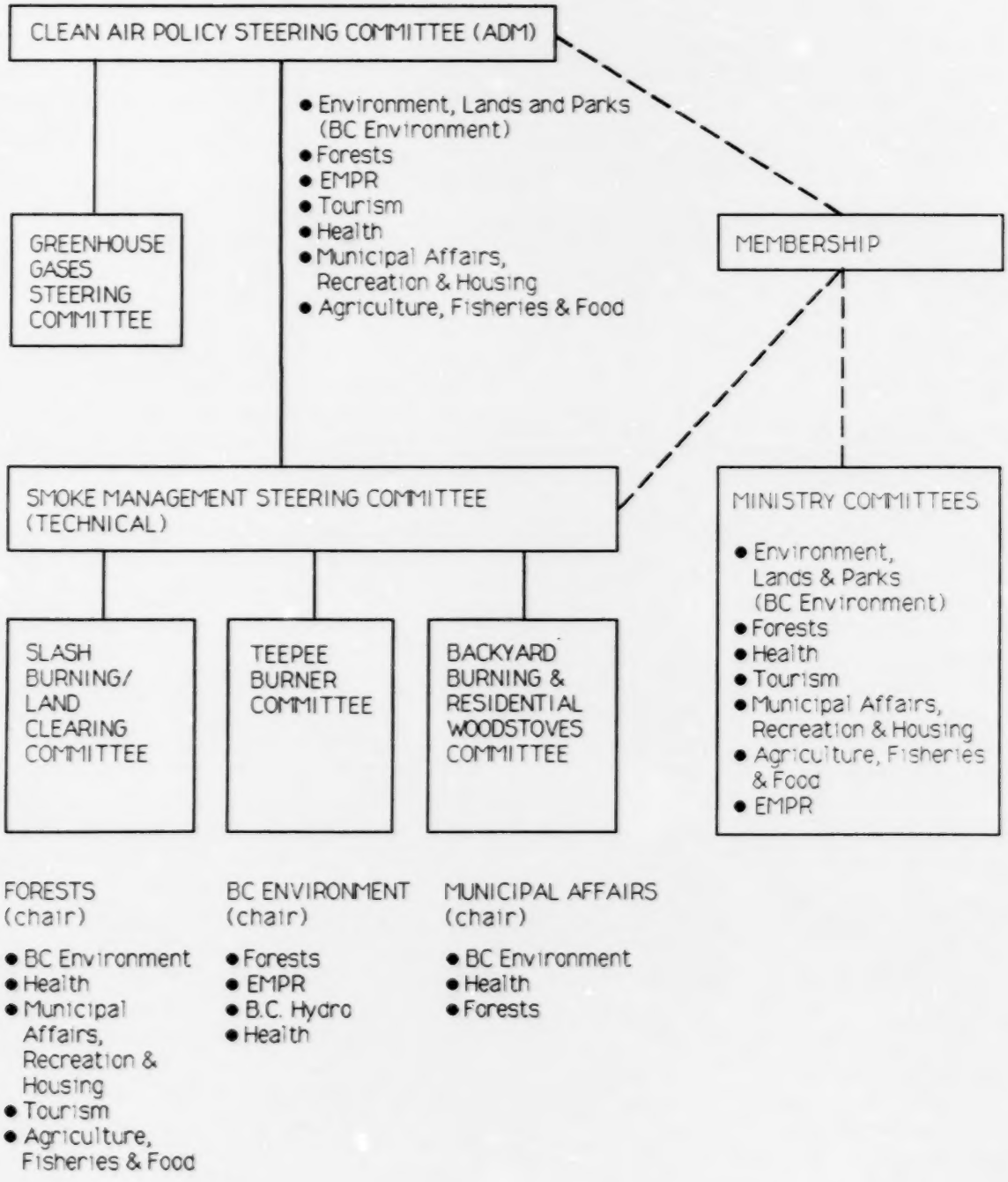
This discussion paper was prepared at the request of the Clean Air Policy Steering Committee to provide one source document that describes all the smoke management issues succinctly and lists possible management approaches. It is intended to guide, but not confine, the discussion of the various working committees, the management committee and the ADMs' committee.

One of the main goals of the Clean Air Policy Steering Committee is to recommend specific management approaches and aid in the development of a clean air policy. In addition, this paper will become an integral part of BC Environment's broader task of developing a clean air strategy for British Columbia. The recommendations will be based on both committee deliberations and an input process for the various stakeholders.

Smoke Management for the '90s is organized by smoke source, much like the committee structure. Each chapter is intended to summarize the concerns about that particular source and list the management approaches. Chapter 3, *Prescribed Burning*, is meant to assist the Slash Burning/Land Clearing Committee, chaired by the Ministry of Forests. *Residue Burning in the Forest Products Industry* (chapter 4) is for the Teepee Burner Committee, chaired by BC Environment. Chapters 5 and 6, *Urban and Agricultural Burning* and *Residential Wood Burning* are for the Backyard Burning and Residential Woodstoves Committee, chaired by the Ministry of Municipal Affairs, Recreation and Housing.

Figure 3

Clean Air Policy Steering Committee



The Smoke Management Steering Committee is not the first body to address smoke issues. In early 1988, the Ministry of Forests created the Smoke Management Working Group to help formulate its interim smoke management policy. Members came from the Council of Forest Industries (COFI) and the Ministries of Health, Environment and Forests. The Ministry of Forests also sought BC Environment's input in 1989, when its prescribed burning policy was under review.

More recently, the B.C. Forest Resources Commission requested a submission from BC Environment on a number of forestry issues, slash burning included. The CO_2 emissions from forestry residue burning have also been studied by the Ministry of Energy, Mines and Petroleum Resources, which found that slash burning in B.C. emits a significant amount of carbon dioxide. However, it must be noted that biomass burning simply quickens the natural process whereby $C0_2$ is released when biomass breaks down, and then reabsorbed by the new, growing forest. The Greenhouse Gases Steering Committee is addressing this question.

APPENDIX 2

The Combustion Process

Freshly cut wood contains between 45% and 55% water, by weight. The remainder consists of a variety of hydrocarbons and other organic compounds:

- cellulose — about 50%;
- lignin — 20% to 30%;
- hemicellulose — 15% to 30%; and
- extractives (including tanins, oils, fats, resins, waxes, starches, glucose, phenol and saccharides).

Combustion is the exothermic process (i.e. it releases heat) whereby a hydrocarbon is oxidized, thus:

$$CH_4 + 2\,O_2 = CO_2 + 2\,H_2O$$

or

Methane (1 Carbon + 4 Hydrogen) + Oxygen = Carbon Dioxide + Water

As impurities are added and/or the hydrocarbon becomes more complex, the chance of more complex byproducts increases. Some of these byproducts are pollutants. For example, adding sulphur to the hydrocarbon forms oxides of sulphur (SO_2, SO_4). If combustion is inefficient due to these impurities, other, more harmful byproducts result. These are generally known as products of incomplete combustion or PICs.

The combustion process takes place in three distinct phases in which increasingly strong molecular bonds are broken as the reaction proceeds. These phases are described briefly below:

1. Pre-ignition — pyrolysis, dehydration and distillation (all endothermic reactions, i.e. absorbing heat) occur at temperatures in the 300-600°C range.

2. Flaming — rapid oxidation and pyro-synthesis (all exothermic reactions) occur at temperatures in the 300-1,400°C range.

3. Glowing — oxidation of the char (carbon) takes place over a wide range of temperatures.

Wet biomass burns poorly because the pre-ignition phase is prolonged, lowering the combustion temperature.

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GLOSSARY

Antisapstain — A fungicide used to treat lumber, to prevent it from staining during storage and shipment.

BCWWECC — B.C. Woodwaste Energy Coordinating Committee.

BDMT — Bone dry metric tonnes.

BDU — Bone dry unit — 2,400 lbs oven-dried hog fuel.

Biomass — The amount of living matter in an area — most of it is plant material and a small quantity is dry animal matter. In general, biomass (wood, vegetation and crop residue) is burned either as a disposal method or to produce energy.

Burner —

1. **Steel-shelled (Teepee, Beehive) Burner** — A common biomass incinerator, conical in shape, which has a steel shell supported by a frame. It has a fuel-delivery system and air inlets. Teepee burners seldom work efficiently because of their simple design and typically poor state of repair.

2. **Refractory Brick (Olivine) Burner** — A new and increasingly common biomass incinerator. It is shaped like a silo and made of large, poured refractory-brick panels supported by a frame. Refractory brick burners usually have an advanced fuel-delivery system (chipping, regulated, and over-fire, under-fire air supplies).

3. **Modified Burner** — After 1975, many burners were "modified" by installing the following combustion-enhancing features:

   - Over-fire air — forced air from the sides to induce a swirling motion and increase efficiency.
   - Under-fire air — forced air from beneath to increase efficiency.
   - Top damper — a series of plates on top to restrict exit gases, retain heat and improve efficiency.
   - Thermometer — to monitor temperature, and regulate fans supplying over-fire air and the top damper.

- Controls — automatic controls have improved efficiency over the old "on-off" systems. They keep the burner at an optimum temperature.

4. **Unmodified Burner** — Before the mid-1970s, nearly all teepee burners in B.C. were "unmodified." They were essentially steel shells surrounding an uncontrolled burn. The air supply came through holes in the shell and there was no temperature control. These burners were notoriously smoky. Most sawmills have switched to modified teepee burners.

Class A and B Permits — Burning permits issued by the Ministry of Forests. **Class A** (commercial) permits are issued for large-scale, "industrial" purposes — for prescribed burning and machine-piled burns.

Class B (casual domestic) permits are issued exclusively for small, hand-piled burns conducted outside incorporated areas.

Cut Block — A specific area with defined boundaries authorized for harvest.

Dioxins and Furans — Dioxins are a family of 75 related chemical compounds. Furans constitute a similar family of 135 compounds. Dioxins and furans share similar biological effects and toxic responses. They occur as unwanted but inevitable contaminants in several processes — such as pulp and paper production, municipal waste incineration and wood burning.

Fire Ecosystem — An ecosystem which has evolved around and is dependent on frequent fires.

Hog Fuel — The biomass left over from sawmill operations, such as bark, wood scraps, shavings and sawdust.

IPP — Independent power producer.

Microgram — One-millionth of a gram.

Micron — One-millionth of a metre (10^{-6}). The period at the end of this sentence is about 500 microns wide.

NO_x — Nitrogen oxides. At low concentrations, NO_x cause bronchial congestion in asthmatics and children. At higher concentrations, they cause fluid buildup in the lungs and fibrotic changes. NO_x contribute to ground-level ozone, acid rain, the greenhouse effect and ozone-layer depletion.

PAHs — Polyaromatic hydrocarbons. A family of chemical compounds found in a variety of natural and manmade sources. The principal concern is that some compounds are strongly mutagenic and carcinogenic.
Particulate Matter (PM)— Fine liquid or solid particles such as dust, smoke, mist fumes or smog, found in the air or emissions.

Pre-Harvest Silvicultural Prescription — A site-specific management strategy, made a legal prerequisite, in 1987, to logging on Crown land. Pre-harvest prescriptions specify planned forest activities, the methods to be used and the proposed constraints necessary to protect the site and its resource values. (Definition supplied by British Columbia Forest Resources Commission.)

Prescribed Burning — A controlled burn, in which the fire is intentionally ignited and allowed to proceed over a designated area within well-defined boundaries. Prescribed burning generally is used for site preparation, to reduce fire danger or to enhance wildlife habitat and cattle range.

Silviculture — The management, care and culture of forest trees; forestry.

Slash — The woody debris left on the ground after logging. It includes tree limbs and leaves, scrub vegetation, unmerchantable timber (rotten, shattered) and decomposing leaf matter (called "duffy material.")

TSP — Total suspended particulates.

VOCs — Volatile organic compounds.

Windrows — Piles of slash, branchwood and debris that have been placed in rows to clear the ground for regeneration. Windrows are often burned.